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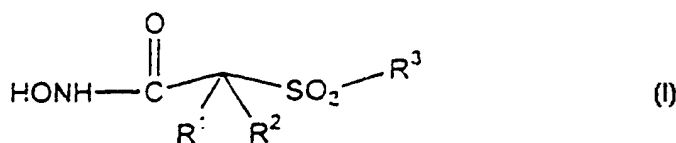
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(54) Title: AROMATIC SULFONE HYDROXAMIC ACID METALLOPROTEASE INHIBITOR



(57) Abstract

A treatment process is disclosed that comprises administering an effective amount of an aromatic sulfone hydroxamic acid that exhibits excellent inhibitory activity of one or more matrix metalloprotease (MMP) enzymes, such as MMP-2, MMP-9 and MMP-13, while exhibiting substantially less inhibition at least of MMP-1 to a host having a condition associated with pathological matrix metalloprotease activity. The administered enzyme inhibitor corresponds in structure to formula (I), below, or a pharmaceutically acceptable salt thereof, wherein R¹ and R² are both hydrido or R¹ and R² together with atoms to which they are bonded form a 5- to 8-membered ring containing one, two or three heteroatoms in the ring that are oxygen, sulfur or nitrogen. R³ in formula (I) is an optionally substituted aryl or optionally substituted heteroaryl radical. Also disclosed are metalloprotease inhibitor compounds having those selective activities, processes for manufacture of such compounds and pharmaceutical compositions using an inhibitor.

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AROMATIC SULFONE HYDROXAMIC ACID
METALLOPROTEASE INHIBITOR

Description

5

Technical Field

This invention is directed to proteinase (protease) inhibitors, and more particularly to the use of aromatic sulfone hydroxamic acid compounds that, *inter alia*, are selective inhibitors of matrix metalloproteinases in a process for treating conditions associated with pathological matrix metalloproteinase activity, the selective inhibitors themselves, compositions of proteinase inhibitors, intermediates for the syntheses of proteinase inhibitors, and processes for the preparation of proteinase inhibitors.

Background of the Invention

Connective tissue, extracellular matrix constituents and basement membranes are required components of all mammals. These components are the biological materials that provide rigidity, differentiation, attachments and, in some cases, elasticity to biological systems including human beings and other mammals. Connective tissues components include, for example, collagen, elastin, proteoglycans, fibronectin and laminin. These biochemicals makeup, or are components of structures, such as skin, bone, teeth, tendon, cartilage, basement membrane, blood vessels, cornea and vitreous humor.

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Under normal conditions, connective tissue turnover and/or repair processes are controlled and in equilibrium. The loss of this balance for whatever reason leads to a number of disease states.

- 5 Inhibition of the enzymes responsible loss of equilibrium provides a control mechanism for this tissue decomposition and, therefore, a treatment for these diseases.

- Degradation of connective tissue or
10 connective tissue components is carried out by the action of proteinase enzymes released from resident tissue cells and/or invading inflammatory or tumor cells. A major class of enzymes involved in this function are the zinc metalloproteinases
15 (metalloproteases).

- The metalloprotease enzymes are divided into classes with some members having several different names in common use. Examples are:
collagenase I (MMP-1, fibroblast collagenase; EC
20 3.4.24.3); collagenase II (MMP-8, neutrophil collagenase; EC 3.4.24.34), collagenase III (MMP-13), stromelysin 1 (MMP-3; EC 3.4.24.17), stromelysin 2 (MMP-10; EC 3.4.24.22), proteoglycanase, matrilysin (MMP-7), gelatinase A (MMP-2, 72 kDa gelatinase,
25 basement membrane collagenase; EC 3.4.24.24), gelatinase B (MMP-9, 92 kDa gelatinase; EC 3.4.24.35), stromelysin 3 (MMP-11), metalloelastase (MMP-12, HME, human macrophage elastase) and membrane MMP (MMP-14). MMP is an abbreviation or acronym
30 representing the term Matrix Metalloprotease with the attached numerals providing differentiation between specific members of the MMP group.

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The uncontrolled breakdown of connective tissue by metalloproteases is a feature of many pathological conditions. Examples include rheumatoid arthritis, osteoarthritis, septic arthritis; corneal, epidermal or gastric ulceration; tumor metastasis, invasion or angiogenesis; periodontal disease; proteinuria; Alzheimers Disease; coronary thrombosis and bone disease. Defective injury repair processes also occur. This can produce improper wound healing leading to weak repairs, adhesions and scarring. These latter defects can lead to disfigurement and/or permanent disabilities as with post-surgical adhesions.

Metalloproteases are also involved in the biosynthesis of tumor necrosis factor (TNF), and inhibition of the production or action of TNF and related compounds is an important clinical disease treatment mechanism. TNF- α , for example, is a cytokine that at present is thought to be produced initially as a 28 kD cell-associated molecule. It is released as an active, 17 kD form that can mediate a large number of deleterious effects *in vitro* and *in vivo*. For example, TNF can cause and/or contribute to the effects of inflammation, rheumatoid arthritis, autoimmune disease, multiple sclerosis, graft rejection, fibrotic disease, cancer, infectious diseases, malaria, mycobacterial infection, meningitis, fever, psoriasis, cardiovascular/pulmonary effects such as post-ischemic reperfusion injury, congestive heart failure, hemorrhage, coagulation, hyperoxic alveolar injury, radiation damage and acute phase responses like those seen with infections and sepsis and during shock such as septic

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shock and hemodynamic shock. Chronic release of active TNF can cause cachexia and anorexia. TNF can be lethal, and TNF can help control the growth of tumor cells.

5 TNF- α convertase is a metalloprotease involved in the formation of soluble TNF- α . Inhibition of TNF- α convertase (TACE) inhibits production of active TNF- α . Compounds that inhibit both MMPs activity and TNF- α production have been
10 disclosed in WIPO International Publication Nos. WO 94/24140, WO 94/02466 and WO 97/20824. Compounds that inhibit MMPs such as collagenase, stromelysin and gelatinase have been shown to inhibit the release of TNF (Gearing et al. *Nature* 376, 555-557 (1994),
15 McGeehan et al., *Nature* 376, 558-561 (1994)). There remains a need for effective MMP inhibitors. There also remains a need for effective TNF- α convertase inhibiting agents.

 MMPs are involved in other biochemical
20 processes in mammals as well. Included is the control of ovulation, post-partum uterine involution, possibly implantation, cleavage of APP (β -Amyloid Precursor Protein) to the amyloid plaque and inactivation of α_1 -protease inhibitor (α_1 -PI).
25 Inhibition of these metalloproteases permits the control of fertility and the treatment or prevention of Alzheimers Disease. In addition, increasing and maintaining the levels of an endogenous or administered serine protease inhibitor drug or
30 biochemical such as α_1 -PI supports the treatment and prevention of diseases such as emphysema, pulmonary

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diseases, inflammatory diseases and diseases of aging such as loss of skin or organ stretch and resiliency.

Inhibition of selected MMPs can also be desirable in other instances. Treatment of cancer and/or inhibition of metastasis and/or inhibition of angiogenesis are examples of approaches to the treatment of diseases wherein the selective inhibition of stromelysin, gelatinase A or B, or collagenase III appear to be the relatively most important enzyme or enzymes to inhibit especially when compared with collagenase I (MMP-1). A drug that does not inhibit collagenase I can have a superior therapeutic profile. Osteoarthritis, another prevalent disease wherein it is believed that cartilage degradation of inflamed joints is at least partially caused by MMP-13 released from cells such as stimulated chondrocytes, may be best treated by administration of drugs one of whose modes of action is inhibition of MMP-13. See, for example, Mitchell et al., *J. Clin. Invest.*, 97:761-768 (1996) and Reboul et al., *J. Clin. Invest.*, 97:2011-2019 (1996).

Inhibitors of metalloproteases are known. Examples include natural biochemicals such as tissue inhibitors of metalloproteinases (TIMPs), α_2 -macroglobulin and their analogs or derivatives. These endogenous inhibitors are high molecular weight protein molecules that form inactive complexes with metalloproteases. A number of smaller peptide-like compounds that inhibit metalloproteases have been described. Mercaptoamide peptidyl derivatives have shown ACE inhibition *in vitro* and *in vivo*. Angiotensin converting enzyme (ACE) aids in the

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production of angiotensin II, a potent pressor substance in mammals and inhibition of this enzyme leads to the lowering of blood pressure.

Thiol group-containing amide or peptidyl amide-based metalloprotease (MMP) inhibitors are known as is shown in, for example, WO95/12389, WO96/11209 and U.S. 4,595,700. Hydroxamate group-containing MMP inhibitors are disclosed in a number of published patent applications such as WO 95/29892, 10 WO 97/24117, WO 97/49679 and EP 0 780 386 that disclose carbon back-boned compounds, and WO 90/05719, WO 93/20047, WO 95/09841 and WO 96/06074 that disclose hydroxamates that have a peptidyl back-bones or peptidomimetic back-bones, as does the 15 article by Schwartz et al., *Progr. Med. Chem.*, 29:271-334 (1992) and those of Rasmussen et al., *Pharmacol. Ther.*, 75(1): 69-75 (1997) and Denis et al., *Invest. New Drugs*, 15(3): 175-185 (1997).

One possible problem associated with known 20 MMP inhibitors is that such compounds often exhibit the same or similar inhibitory effects against each of the MMP enzymes. For example, the peptidomimetic hydroxamate known as batimastat is reported to exhibit IC₅₀ values of about 1 to about 20 nanomolar 25 (nM) against each of MMP-1, MMP-2, MMP-3, MMP-7, and MMP-9. Marimastat, another peptidomimetic hydroxamate was reported to be another broad-spectrum MMP inhibitor with an enzyme inhibitory spectrum very similar to batimastat, except that marimastat 30 exhibited an IC₅₀ value against MMP-3 of 230 nM. Rasmussen et al., *Pharmacol. Ther.*, 75(1): 69-75 (1997).

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Meta analysis of data from Phase I/II studies using marimastat in patients with advanced, rapidly progressive, treatment-refractory solid tumor cancers (colorectal, pancreatic, ovarian, prostate) indicated a dose-related reduction in the rise of cancer-specific antigens used as surrogate markers for biological activity. Although marimastat exhibited some measure of efficacy via these markers, toxic side effects were noted. The most common drug-related toxicity of marimastat in those clinical trials was musculoskeletal pain and stiffness, often commencing in the small joints in the hands, spreading to the arms and shoulder. A short dosing holiday of 1-3 weeks followed by dosage reduction permits treatment to continue. Rasmussen et al., *Pharmacol. Ther.*, 75(1): 69-75 (1997). It is thought that the lack of specificity of inhibitory effect among the MMPs may be the cause of that effect.

International application WO 98/38163, published on September 3, 1998 disclose a large group of hydroxamate inhibitors of MMPs and TACE. The compounds of WO 98/38163 contain one or two substituents adjacent to the hydroxamate functionality and a substituent that can be an aromatic sulfonyl group adjacent to those one or two substituents.

International application WO 98/37877, published on September 3, 1998 discloses compounds that contain a 5- to 7-membered heterocyclic ring adjacent to the hydroxamate functionality and can

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contain an aromatic sulfonyl group adjacent to the heterocyclic ring.

Although many of the known MMP inhibitors such as batimastat, marimastat and the hydroxamates of WO 98/37877 and WO 98/38163 exhibit a broad spectrum of activity against MMPs, those compounds are not particularly selective in their inhibitory activity. This lack of selectivity may be the cause of the musculoskeletal pain and stiffness observed with their use. In addition, it can be therapeutically advantageous to utilize a medicament that is selective in its activity as compared to a generally active material so that treatment can be more closely tailored to the pathological condition presented by the host mammal. The disclosure that follows describes a process for treating a host mammal having a condition associated with pathological matrix metalloprotease activity that utilizes a compound that selectively inhibits one or more MMPs, while exhibiting less activity against at least MMP-1.

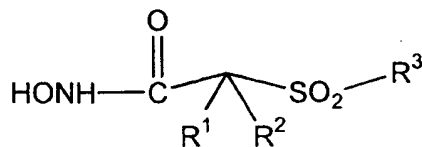
Summary of the Invention

The present invention is directed to a treatment process that comprises administering a contemplated aromatic sulfone hydroxamic acid metalloprotease inhibitor in an effective amount to a host mammal having a condition associated with pathological metalloprotease activity. A contemplated molecule, *inter alia*, exhibits excellent inhibitory activity of one or more matrix

metalloprotease (MMP) enzymes, such as MMP-2, MMP-9 and MMP-13, while exhibiting substantially less inhibition at least of MMP-1. By "substantially less" it is meant that a contemplated compound
5 exhibits an IC_{50} value ratio against one or more of MMP-2, MMP-9 or MMP-13 as compared to its IC_{50} value against MMP-1, e.g., IC_{50} MMP-2: IC_{50} MMP-1, that is less than about 1:10, preferably less than about 1:100, and most preferably less than about 1:1000 in
10 the *in vitro* inhibition assay utilized hereinafter. The invention also contemplates particular compounds that selectively inhibit the activity of one or more of MMP-2, MMP-9 and MMP-13, while exhibiting substantially less inhibition at least of MMP-1, as
15 well as a composition containing such a MMP inhibitor as active ingredient. The invention further contemplates intermediates in the preparation of a contemplated aromatic sulfone hydroxamic acid molecule and a process for preparing an aromatic
20 sulfone hydroxamic acid molecule.

Briefly, one embodiment of the present invention is directed to a treatment process that comprises administering a contemplated aromatic sulfone hydroxamic acid metalloprotease inhibitor
25 that selectively inhibits matrix metalloprotease activity as above in an effective amount to a host mammal having a condition associated with pathological metalloprotease activity. The administered enzyme inhibitor corresponds in
30 structure to formula (I), below, or a pharmaceutically acceptable salt thereof:

-10-



I

wherein

5 R^1 and R^2 are both hydrido or R^1 and R^2 together with the atoms to which they are bonded form a 5- to 8-membered ring containing one, two or three heteroatoms in the ring that are oxygen, sulfur or nitrogen.

10 R^3 in formula I is an optionally substituted aryl or optionally substituted heteroaryl radical. When R^3 is a substituted aryl or heteroaryl radical, a contemplated substituent is selected from the group consisting of an aryl, heteroaryl, aralkyl,

15 heteroaralkyl, aryloxy, arylthio, aralkoxy, heteroaralkoxy, aralkoxyalkyl, aryloxyalkyl, aralkanoylalkyl, arylcarbonylalkyl, aralkylaryl, aryloxyalkylaryl, aralkoxyaryl, arylazoaryl, arylhydrazinoaryl, alkylthioaryl, arylthioalkyl,

20 alkylthioaralkyl, aralkylthioalkyl, an aralkylthioaryl radical, the sulfoxide or sulfone of any of the thio substituents, and a fused ring structure comprising two or more 5- or 6-membered rings selected from the group consisting of aryl,

25 heteroaryl, carbocyclic and heterocyclic.

The substituent bonded to the aryl or heteroaryl radical of which the R^3 radical is comprised itself can be substituted with one or more substituents;

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i.e., the substituting substituent is optionally substituted. When that aryl or heteroaryl radical is substituted, and the substituting moiety (group, substituent, or radical) is itself substituted, the last-named substituent is independently selected from the group consisting of a cyano, perfluoroalkyl, trifluoromethoxy, trifluoromethylthio, haloalkyl, trifluoromethylalkyl, aralkoxycarbonyl, aryloxycarbonyl, hydroxy, halo, alkyl, alkoxy, nitro, thiol, hydroxycarbonyl, aryloxy, arylthio, aralkyl, aryl, arylcarbonylamino, heteroaryloxy, heteroarylthio, heteroaralkyl, cycloalkyl, heterocyclooxy, heterocyclothio, heterocycloamino, cycloalkyloxy, cycloalkylthio, heteroaralkoxy, heteroaralkylthio, aralkoxy, aralkylthio, aralkylamino, heterocyclo, heteroaryl, arylazo, hydroxycarbonylalkoxy, alkoxycarbonylalkoxy, alkanoyl, arylcarbonyl, aralkanoyl, alkanoyloxy, aralkanoyloxy, hydroxyalkyl, hydroxyalkoxy, alkylthio, alkoxyalkylthio, alkoxycarbonyl, aryloxyalkoxyaryl, arylthioalkylthioaryl, aryloxyalkylthioaryl, arylthioalkoxyaryl, hydroxycarbonylalkoxy, hydroxycarbonylalkylthio, alkoxycarbonylalkoxy, alkoxycarbonylalkylthio, amino, wherein the amino nitrogen is (i) unsubstituted, or (ii) substituted with one or two substituents that are independently selected from the group consisting of an alkyl, aryl, heteroaryl, aralkyl, cycloalkyl, aralkoxycarbonyl, alkoxycarbonyl, arylcarbonyl, aralkanoyl, heteroarylcarbonyl, heteroaralkanoyl and an alkanoyl group, or (iii) wherein the amino nitrogen and two substituents attached thereto

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form a 5- to 8-membered heterocyclo or heteroaryl ring containing zero to two additional heteroatoms that are nitrogen, oxygen or sulfur and which ring itself is (a) unsubstituted or (b) substituted with one or two groups independently selected from the group consisting of an aryl, alkyl, heteroaryl, aralkyl, heteroaralkyl, hydroxy, alkoxy, alkanoyl, cycloalkyl, heterocycloalkyl, alkoxy carbonyl, hydroxyalkyl, trifluoromethyl, benzofused heterocycloalkyl, hydroxyalkoxyalkyl, aralkoxy carbonyl, hydroxycarbonyl, aryloxy carbonyl, benzofused heterocycloalkoxy, benzofused cycloalkyl carbonyl, heterocycloalkyl carbonyl, and a cycloalkyl carbonyl group, carbonylamino

wherein the carbonylamino nitrogen is (i) unsubstituted, or (ii) is the reacted amine of an amino acid, or (iii) substituted with one or two radicals selected from the group consisting of an alkyl, hydroxyalkyl, hydroxyheteroaralkyl, cycloalkyl, aralkyl, trifluoromethylalkyl, heterocycloalkyl, benzofused heterocycloalkyl, benzofused heterocycloalkyl, benzofused cycloalkyl, and an N,N-dialkylsubstituted alkylamino-alkyl group, or (iv) the carboxamido nitrogen and two substituents bonded thereto together form a 5- to 8-membered heterocyclo, heteroaryl or benzofused heterocycloalkyl ring that is itself unsubstituted or substituted with one or two radicals independently selected from the group consisting of an alkyl, alkoxy carbonyl, nitro, heterocycloalkyl,

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hydroxy, hydroxycarbonyl, aryl, aralkyl,
heteroaralkyl and an amino group,

wherein the amino nitrogen is

(i) unsubstituted, or (ii) substituted with

5 one or two substituents that are

independently selected from the group

consisting of alkyl, aryl, and heteroaryl,

or (iii) wherein the amino nitrogen and two
substituents attached thereto form a 5- to

10 8-membered heterocyclo or heteroaryl ring,

and an aminoalkyl group

wherein the aminoalkyl nitrogen is (i) unsubstituted,

or (ii) substituted with one or two substituents

independently selected from the group consisting of

15 an alkyl, aryl, aralkyl, cycloalkyl,

aralkoxycarbonyl, alkoxycarbonyl, and an alkanoyl

group, or (iii) wherein the aminoalkyl nitrogen and

two substituents attached thereto form a 5- to 8-

membered heterocyclo or heteroaryl ring.

20 In preferred practice, R^1 and R^2 together

with the atoms to which they are bonded form a

6-membered ring.

An R^3 radical preferably has a length that
is greater than that of a pentyl group [a $-(CH_2)_4CH_3$

25 chain] and more preferably greater than about that of

a hexyl group [a $-(CH_2)_5CH_3$ chain]. An R^3 radical

preferably has a length that is less than that of an

icosyl group [a $-(CH_2)_{19}CH_3$ chain], and more

preferably a length that is less than that of a

30 stearyl group [a $-(CH_2)_{17}CH_3$ chain]. A preferred R^3

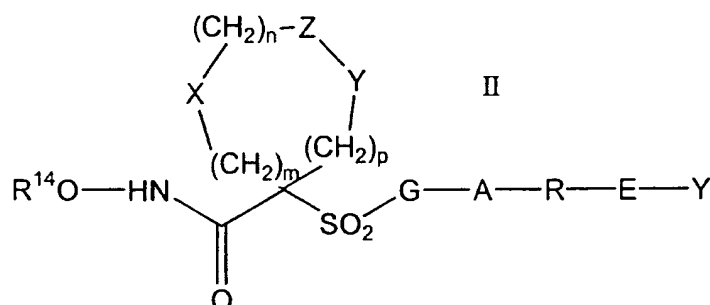
group contains two or more 5- or 6-membered rings. A

contemplated R^3 group, when rotated about an axis drawn through the SO_2 -bonded 1-position and the substituent-bonded 4-position of a 6-membered ring or the SO_2 -bonded 1-position and substituent-bonded 3-
5 or 4-position of a 5-membered ring, defines a three-dimensional volume whose widest dimension has the width in a direction transverse to that axis to rotation of about one furanyl ring to about two phenyl rings.

10 It is also preferred that a R^3 radical be a single-ringed aryl or heteroaryl group that is 5- or 6-membered, and is itself substituted at its own 4-position when a 6-membered ring or at its own 3- or 4-position when a 5-membered ring with an optionally
15 substituted substituent selected from the group consisting of one other single-ringed aryl or heteroaryl group, a C_3 - C_{14} alkyl group, a N-piperidyl group, a N-piperazyl group, a phenoxy group, a thiophenoxy group, a 4-thiopyridyl group, a phenylazo
20 group and a benzamido group. The substituent of the 5- or 6-membered aryl or heteroaryl group can itself be substituted as discussed before.

A preferred compound for use in a contemplated process has a structure that corresponds to formula
25 II, below, or a pharmaceutically acceptable salt thereof:

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wherein

R^{14} is hydrido, a pharmaceutically

- 5 acceptable cation or $C(W)R^{15}$ where W is O or S and R^{15} is selected from the group consisting of an C_1 - C_6 -alkyl, aryl, C_1 - C_6 -alkoxy, heteroaryl- C_1 - C_6 -alkyl, C_3 - C_8 -cycloalkyl- C_1 - C_6 -alkyl, aryloxy, ar- C_1 - C_6 -alkoxy, ar- C_1 - C_6 -alkyl, heteroaryl and amino C_1 - C_6 -alkyl group wherein the aminoalkyl nitrogen is (i) unsubstituted or (ii) substituted with one or two substituents independently selected from the group consisting of an C_1 - C_6 -alkyl, aryl, ar- C_1 - C_6 -alkyl, C_3 - C_8 -cycloalkyl- C_1 - C_6 -alkyl, ar- C_1 - C_6 -alkoxycarbonyl, C_1 - C_6 -alkoxycarbonyl, and C_1 - C_6 -alkanoyl radical, or (iii) wherein the amino C_1 - C_6 -alkyl nitrogen and two substituents attached thereto form a 5- to 8-membered heterocyclo or heteroaryl ring;

20 m is zero, 1 or 2;

n is zero, 1 or 2;

p is zero, 1 or 2;

the sum of $m + n + p = 1, 2, 3$ or 4;

- (a) one of X, Y and Z is selected from the
25 group consisting of $C(O)$, NR^6 , O, S, $S(O)$, $S(O)_2$ and

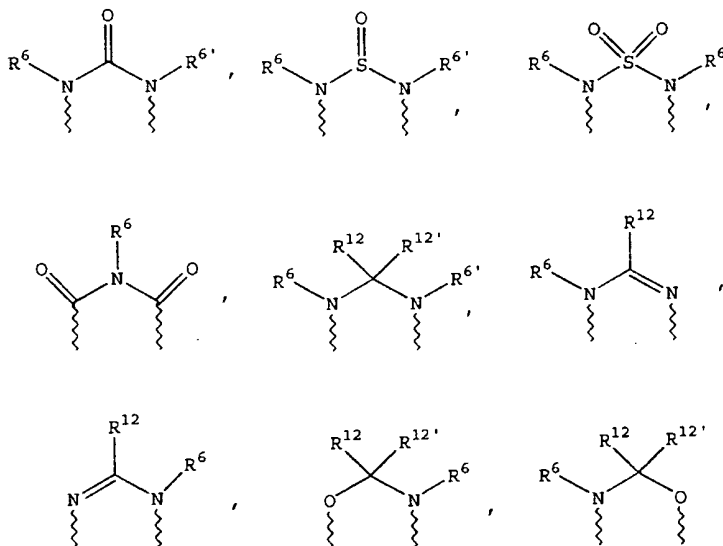
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$\text{NS(O)}_2\text{R}^7$, and the remaining two of X, Y and Z are

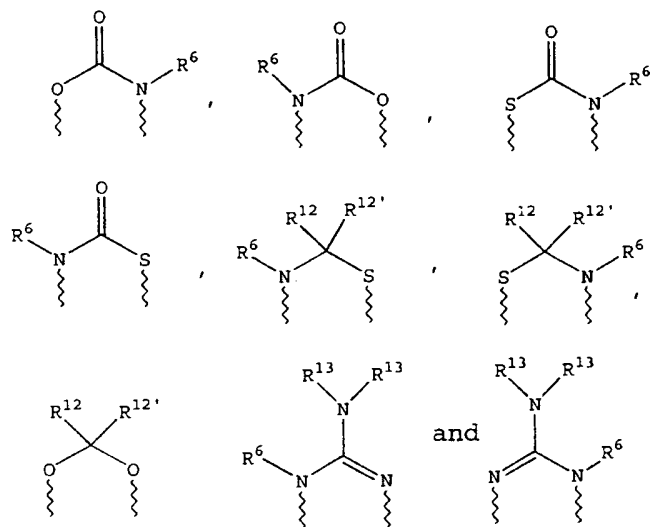
CR^8R^9 , and $\text{CR}^{10}\text{R}^{11}$, or

(b) X and Z or Z and Y together constitute a moiety that is selected from the group consisting
 5 of $\text{NR}^6\text{C(O)}$, $\text{NR}^6\text{S(O)}$, $\text{NR}^6\text{S(O)}_2$, NR^6S , NR^6O , SS , NR^6NR^6 and OC(O) , with the remaining one of X, Y and Z being CR^8R^9 , or

(c) n is zero and X, Y and Z together constitute a moiety selected from the group
 10 consisting of



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wherein wavy lines are bonds to the atoms of the depicted ring;

- 5 R^6 and $\text{R}^{6'}$ are independently selected from the group consisting of hydrido, C_1 - C_6 -alkanoyl, C_6 -aryl- C_1 - C_6 -alkyl, aroyl, bis(C_1 - C_6 -alkoxy- C_1 - C_6 -alkyl)- C_1 - C_6 -alkyl, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -perfluoroalkyl, C_1 - C_6 -trifluoromethylalkyl, C_1 - C_6 -perfluoroalkoxy- C_1 - C_6 -alkyl, C_1 - C_6 -alkoxy- C_1 - C_6 -alkyl, C_3 - C_6 -cycloalkyl, C_3 - C_8 -heterocycloalkyl, C_3 - C_8 -heterocycloalkylcarbonyl, C_6 -aryl, C_5 - C_6 -heterocyclo, C_5 - C_6 -heteroaryl, C_3 - C_8 -cycloalkyl- C_1 - C_6 -alkyl, C_6 -aryloxy- C_1 - C_6 -alkyl, heteroaryloxy- C_1 - C_6 -alkyl, heteroaryl- C_1 - C_6 -alkoxy- C_1 - C_6 -alkyl, heteroarylthio- C_1 - C_6 -alkyl, C_6 -arylsulfonyl, C_1 - C_6 -alkylsulfonyl, C_5 - C_6 -heteroarylsulfonyl, carboxy- C_1 - C_6 -alkyl, C_1 - C_4 -alkoxycarbonyl- C_1 - C_6 -alkyl, aminocarbonyl, C_1 - C_6 -alkyliminocarbonyl, C_6 -

aryliminocarbonyl, C₅-C₆-heterocycloiminocarbonyl,
C₆-arylthio-C₁-C₆-alkyl, C₁-C₆-alkylthio-C₁-C₆-alkyl,
C₆-arylthio-C₃-C₆-alkenyl, C₁-C₄-alkylthio-C₃-C₆-
alkenyl, C₅-C₆-heteroaryl-C₁-C₆-alkyl, halo-C₁-C₆-
5 alkanoyl, hydroxy-C₁-C₆-alkanoyl, thiol-C₁-C₆-
alkanoyl, C₃-C₆-alkenyl, C₃-C₆-alkynyl, C₁-C₄-alkoxy-
C₁-C₄-alkyl, C₁-C₅-alkoxycarbonyl, aryloxycarbonyl,
NR⁸R⁹-C₁-C₅-alkylcarbonyl, hydroxy-C₁-C₅-alkyl, an
aminocarbonyl wherein the aminocarbonyl nitrogen is
10 (i) unsubstituted or (ii) substituted with one or two
radicals independently selected from the group
consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, C₃-C₈-
cycloalkyl and a C₁-C₆-alkanoyl group,
hydroxyaminocarbonyl, an aminosulfonyl group wherein
15 the aminosulfonyl nitrogen is (i) unsubstituted or
(ii) substituted with one or two radicals
independently selected from the group consisting of
C₁-C₆-alkyl, ar-C₁-C₆-alkyl, C₃-C₈-cycloalkyl and a
C₁-C₆-alkanoyl group, an amino-C₁-C₆-alkylsulfonyl
20 group wherein the amino-C₁-C₆-alkylsulfonyl nitrogen
is (i) unsubstituted or (ii) substituted with one or
two radicals independently selected from the group
consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, C₃-C₈-
cycloalkyl and a C₁-C₆-alkanoyl group and an amino-
25 C₁-C₆-alkyl group wherein the aminoalkyl nitrogen is
(i) unsubstituted or (ii) substituted with one or two
radicals independently selected from the group
consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, C₃-C₈-
cycloalkyl and a C₁-C₆-alkanoyl group;

R^7 is selected from the group consisting of a arylalkyl, aryl, heteroaryl, heterocyclo, C_1 - C_6 -alkyl, C_3 - C_6 -alkynyl, C_3 - C_6 -alkenyl, C_1 - C_6 -carboxyalkyl and a C_1 - C_6 -hydroxyalkyl group;

- 5 R^8 and R^9 and R^{10} and R^{11} are independently selected from the group consisting of a hydrido, hydroxy, C_1 - C_6 -alkyl, aryl, ar- C_1 - C_6 -alkyl, heteroaryl, heteroar- C_1 - C_6 -alkyl, C_2 - C_6 -alkynyl, C_2 - C_6 -alkenyl, thiol- C_1 - C_6 -alkyl, C_1 - C_6 -alkylthio- C_1 - C_6 -
10 alkyl cycloalkyl, cycloalkyl- C_1 - C_6 -alkyl, heterocycloalkyl- C_1 - C_6 -alkyl, C_1 - C_6 -alkoxy- C_1 - C_6 -alkyl, aralkoxy- C_1 - C_6 -alkyl, C_1 - C_6 -alkoxy- C_1 - C_6 -alkoxy- C_1 - C_6 -alkyl, hydroxy- C_1 - C_6 -alkyl, hydroxycarbonyl- C_1 - C_6 -alkyl, hydroxycarbonylar- C_1 - C_6 -
15 alkyl, aminocarbonyl- C_1 - C_6 -alkyl, aryloxy- C_1 - C_6 -alkyl, heteroaryloxy- C_1 - C_6 -alkyl, arylthio- C_1 - C_6 -alkyl, heteroarylthio- C_1 - C_6 -alkyl, the sulfoxide or sulfone of any said thio substituents, perfluoro- C_1 - C_6 -alkyl, trifluoromethyl- C_1 - C_6 -alkyl, halo- C_1 - C_6 -
20 alkyl, alkoxycarbonylamino- C_1 - C_6 -alkyl and an amino- C_1 - C_6 -alkyl group wherein the aminoalkyl nitrogen is (i) unsubstituted or (ii) substituted with one or two radicals independently selected from the group consisting of C_1 - C_6 -alkyl, ar- C_1 - C_6 -alkyl, cycloalkyl
25 and C_1 - C_6 -alkanoyl, or wherein R^8 and R^9 or R^{10} and R^{11} and the carbon to which they are bonded form a carbonyl group, or wherein R^8 and R^9 or R^{10} and R^{11} , or R^8 and R^{10} together with the atoms to which they

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are bonded form a 5- to 8-membered carbocyclic ring, or a 5- to 8-membered heterocyclic ring containing one or two heteroatoms that are nitrogen, oxygen, or sulfur, with the proviso that only one of R⁸ and R⁹ or R¹⁰ and R¹¹ is hydroxy;

R¹² and R^{12'} are independently selected from the group consisting of a hydrido, C₁-C₆-alkyl, aryl, ar-C₁-C₆-alkyl, heteroaryl, heteroaralkyl, C₂-C₆-alkynyl, C₂-C₆-alkenyl, thiol-C₁-C₆-alkyl, cycloalkyl, cycloalkyl-C₁-C₆-alkyl, heterocycloalkyl-C₁-C₆-alkyl, C₁-C₆-alkoxy-C₁-C₆-alkyl, aryloxy-C₁-C₆-alkyl, amino-C₁-C₆-alkyl, C₁-C₆-alkoxy-C₁-C₆-alkoxy-C₁-C₆-alkyl, hydroxy-C₁-C₆-alkyl, hydroxycarbonyl-C₁-C₆-alkyl, hydroxycarbonylar-C₁-C₆-alkyl, aminocarbonyl-C₁-C₆-alkyl, aryloxy-C₁-C₆-alkyl, heteroaryloxy-C₁-C₆-alkyl, C₁-C₆-alkylthio-C₁-C₆-alkyl, arylthio-C₁-C₆-alkyl, heteroarylthio-C₁-C₆-alkyl, the sulfoxide or sulfone of any said thio substituents, perfluoro-C₁-C₆-alkyl, trifluoromethyl-C₁-C₆-alkyl, halo-C₁-C₆-alkyl, alkoxycarbonylamino-C₁-C₆-alkyl and an amino-C₁-C₆-alkyl group wherein the aminoalkyl nitrogen is (i) unsubstituted or (ii) substituted with one or two radicals independently selected from the group consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, cycloalkyl and C₁-C₆-alkanoyl;

R¹³ is selected from the group consisting of a hydrido, benzyl, phenyl, C₁-C₆-alkyl, C₂-C₆-alkynyl, C₂-C₆-alkenyl and a C₁-C₆-hydroxyalkyl group; and

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G-A-R-E-Y is a substituent that preferably has a length greater than that of a pentyl group, and more preferably has a length greater than that of a hexyl group. The substituent G-A-R-E-Y preferably has a
5 length that is less than that of an icosyl group, and is more preferably less than that of a stearyl group. In this substituent:

G is an aryl or heteroaryl group;

A is selected from the group consisting of

- 10 (1) -O-;
(2) -S-;
(3) -NR¹⁷-;
(4) -CO-N(R¹⁷) or -N(R¹⁷)-CO-, wherein R¹⁷ is hydrogen, C₁-C₄-alkyl, or phenyl;
15 (5) -CO-O- or -O-CO-;
(6) -O-CO-O-;
(7) -HC=CH-;
(8) -NH-CO-NH-;
(9) -C≡C-;
20 (10) -NH-CO-O- or -O-CO-NH-;
(11) -N=N-;
(12) -NH-NH-; and
(13) -CS-N(R¹⁸)- or -N(R¹⁸)-CS-, wherein R¹⁸ is hydrogen C₁-C₄-alkyl, or
25 phenyl; or
(14) A is absent and G is bonded directly to R;

R is a moiety selected from the group consisting of alkyl, alkoxyalkyl, aryl, heteroaryl,
30 cycloalkyl, heterocycloalkyl, aralkyl, heteroaralkyl,

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heterocycloalkylalkyl, cycloalkylalkyl,
cycloalkoxyalkyl, heterocycloalkoxyalkyl,
aryloxyalkyl, heteroaryloxyalkyl, arylthioalkyl,
heteroarylthioalkyl, cycloalkylthioalkyl, and a
5 heterocycloalkylthioalkyl group wherein the aryl or
heteroaryl or cycloalkyl or heterocycloalkyl
substituent is (i) unsubstituted or (ii) substituted
with one or two radicals selected from the group
consisting of a halo, alkyl, perfluoroalkyl,
10 perfluoroalkoxy, perfluoroalkylthio,
trifluoromethylalkyl, amino, alkoxycarbonylalkyl,
alkoxy, C₁-C₂-alkylene-dioxy, hydroxycarbonylalkyl,
hydroxycarbonylalkylamino, nitro, hydroxy,
hydroxyalkyl, alkanoylamino, and a alkoxycarbonyl
15 group, and R is other than alkyl or alkoxyalkyl when
A is -O- or -S-;

E is selected from the group consisting of

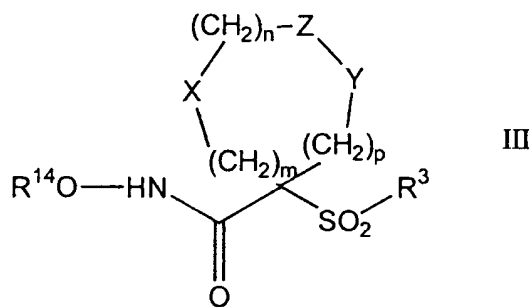
- (1) -CO(R¹⁹)- or -(R¹⁹)CO-, wherein R¹⁹ is
a heterocycloalkyl, or a cycloalkyl
20 group;
- (2) -CONH- or -HNCO-; and
- (3) -CO-;
- (4) -SO₂-R¹⁹- or -R¹⁹-SO₂-;
- (5) -SO₂-;
- 25 (6) -NH-SO₂- or -SO₂-NH-; or
- (7) E is absent and R is bonded directly
to Y; and

Y is absent or is selected from the group
consisting of a hydrido, alkyl, alkoxy, haloalkyl,
30 aryl, aralkyl, cycloalkyl, heteroaryl, hydroxy,

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aryloxy, aralkoxy, heteroaryloxy, heteroaralkyl,
 perfluoroalkoxy, perfluoroalkylthio,
 trifluoromethylalkyl, alkenyl, heterocycloalkyl,
 cycloalkyl, trifluoromethyl, alkoxy, carbonyl, and a
 5 aminoalkyl group, wherein the aryl or heteroaryl or
 heterocycloalkyl group is (i) unsubstituted or (ii)
 substituted with one or two radicals independently
 selected from the group consisting of an alkanoyl,
 halo, nitro, aralkyl, aryl, alkoxy, and an amino
 10 group wherein the amino nitrogen is (i) unsubstituted
 or (ii) substituted with one or two groups
 independently selected from hydrido, alkyl, and an
 aralkyl group.

A particularly preferred compound for use
 15 in a contemplated process corresponds in structure to
 formula III, below, or a pharmaceutically acceptable
 salt thereof:



20

wherein

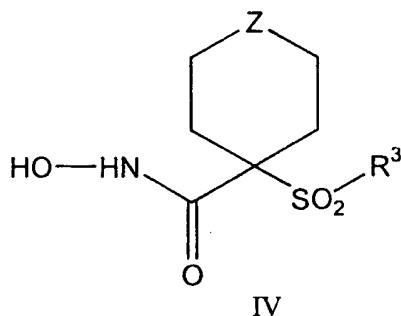
m, n, p, X, Z, Y and R¹⁴ are as defined above
 for formula II, and the R³ radical that is defined

below is a sub-set of the previously discussed G-A-R-E-Y substituents.

Thus, R³ is a radical that is comprised of a single-ringed aryl or heteroaryl group that is 5- or 6-membered, and is itself substituted at its own 4-position when a 6-membered ring and at its own 3- or 4-position when a 5-membered ring with a substituent selected from the group consisting of a thiophenoxy, 4-chlorophenoxy, 3-chlorophenoxy, 4-methoxyphenoxy, 3-benzodioxol-5-yloxy, 3,4-dimethylphenoxy, 4-fluorophenoxy, 4-fluorothiophenoxy, phenoxy, 4-trifluoromethoxy-phenoxy, 4-trifluoromethylphenoxy, 4-(trifluoromethylthio)-phenoxy, 4-(trifluoromethylthio)-thiophenoxy, 4-chloro-3-fluorophenoxy, 4-isopropoxyphenoxy, 4-isopropylphenoxy, (2-methyl-1,3-benzothiazol-5-yl)oxy, 4-(1H-imidazol-1-yl)phenoxy, 4-chloro-3-methylphenoxy, 3-methylphenoxy, 4-ethoxyphenoxy, 3,4-difluorophenoxy, 4-chloro-3-methylphenoxy, 4-fluoro-3-chlorophenoxy, 4-(1H-1,2,4-triazol-1-yl)phenoxy, 3,5-difluorophenoxy, 3,4-dichlorophenoxy, 4-cyclopentylphenoxy, 4-bromo-3-methylphenoxy, 4-bromophenoxy, 4-methylthiophenoxy, 4-phenylphenoxy, 4-benzylphenoxy, 6-quinolinylxy, 4-amino-3-methylphenoxy, 3-methoxyphenoxy, 5,6,7,8-tetrahydro-2-naphthalenyloxy, 3-hydroxymethylphenoxy, N-piperidyl, N-piperazinyl and a 4-benzyloxyphenoxy group.

A more particularly preferred compound for use in a contemplated process has a structure that corresponds to formula IV, below, or a pharmaceutically acceptable salt thereof:

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wherein R^3 is as defined above for formula I,
 5 more preferably as defined for formula II (wherein
 this R^3 group is the G-A-R-E-Y substituent), and more
 preferably still as defined for formula III, and

Z is selected group the group consisting of O,
 S, NR^6 , SO, SO_2 , and NSO_2R^7 ,

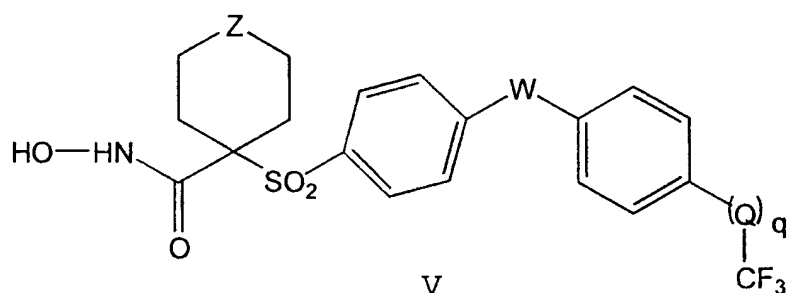
10 wherein R^6 is selected from the group consisting
 of hydrido, C_1 - C_5 -alkyl, C_1 - C_5 -alkanoyl, benzyl,
 benzoyl, C_3 - C_5 -alkynyl, C_3 - C_5 -alkenyl, C_1 - C_3 -alkoxy-
 C_1 - C_4 -alkyl, C_3 - C_6 -cycloalkyl, heteroaryl- C_1 - C_6 -
 alkyl, C_1 - C_5 -hydroxyalkyl, C_1 - C_5 -carboxyalkyl, C_1 - C_5 -
 15 alkoxy C_1 - C_5 -alkylcarbonyl, and NR^8R^9 - C_1 - C_5 -
 alkylcarbonyl or NR^8R^9 - C_1 - C_5 -alkyl wherein R^8 and R^9
 are independently hydrido, C_1 - C_5 -alkyl, C_1 - C_5 -
 alkoxycarbonyl or aryl- C_1 - C_5 -alkoxycarbonyl, or NR^8R^9
 together form a heterocyclic ring containing 5- to 8-
 20 atoms in the ring; and

R^7 is selected from the group consisting of an
 arylalkyl, aryl, heteroaryl, heterocyclo, C_1 - C_6 -

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alkyl, C₃-C₆-alkynyl, C₃-C₆-alkenyl, C₁-C₆-carboxyalkyl and a C₁-C₆-hydroxyalkyl group.

A still more preferred group of compounds for use in a contemplated process correspond in structure to formula V, below, or a pharmaceutically acceptable salt thereof:



10 wherein

Z is as previously defined in formula IV;

W and Q are independently oxygen (O), NR⁶ or sulfur (S), and R⁶ is as defined in formula IV; and

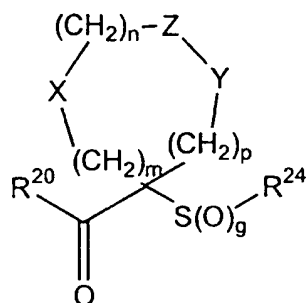
q is zero or one such that when q is zero, the
15 trifluoromethyl group is bonded directly to the depicted phenyl ring.

The use of a compound of formulas I-V, or a pharmaceutically acceptable salt of one of those compounds is contemplated in a before-described
20 process. In addition, the compounds of formulas II, III, IV and V, and their pharmaceutically acceptable salts are contemplated compounds of this invention.

The present invention also contemplates a precursor or intermediate compound that is useful in
25 preparing a compound of formulas I-V. Such an

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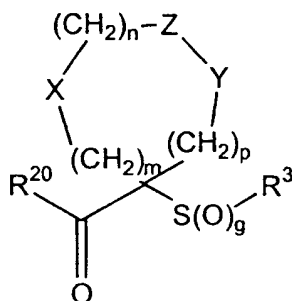
intermediate compound corresponds in structure to formula VI, below:



VI

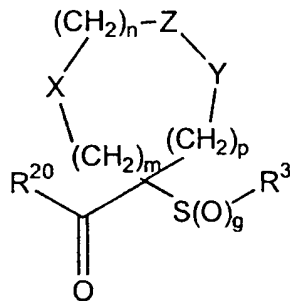
5

wherein m, n, p, X, Z and Y are as defined above for formula II, g is zero, 1 or 2 and R²⁴ is R³ as defined in formulas I, III or IV, is the
 10 substituent G-A-R-E-Y of formula II (formula VIA) or is R^{3'}, an aryl or heteroaryl group that is substituted with a coupling substituent reactive for coupling with another moiety (formula VIB), such as a nucleophilically displaceable leaving group, D.



VIA

15



VIB

Exemplary nucleophilically displaceable leaving groups, D, include a halo (fluoro, chloro, bromo, or iodo) nitro, azido, phenylsulfoxido,

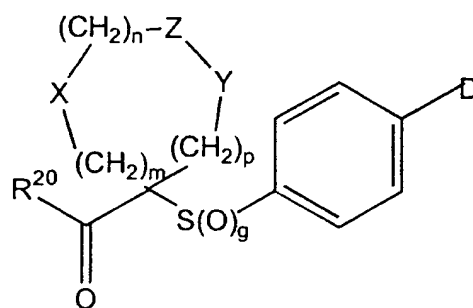
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aryloxy, C₁-C₆-alkoxy, a C₁-C₆-alkylsulfonate or arylsulfonate group and a trisubstituted ammonium group in which the three substituents are independently aryl, ar-C₁-C₆-alkyl or C₁-C₆-alkyl.

5 R²⁰ is (a) -O-R²¹, where R²¹ is selected from the group consisting of a hydrido, C₁-C₆-alkyl, aryl, ar-C₁-C₆-alkyl group and a pharmaceutically acceptable cation, or (b) -NH-O-R²² wherein R²² is a selectively removable protecting group such as a 2-
10 tetrahydropyranyl, C₁-C₆-acyl, aroyl, benzyl, p-methoxybenzyloxycarbonyl (MOZ), benzyloxycarbonyl, C₁-C₆-alkoxycarbonyl, C₁-C₆-alkoxy-CH₂-, C₁-C₆-alkoxy-C₁-C₆-alkoxy-CH₂-, trisubstituted silyl group or o-nitrophenyl group, peptide synthesis resin and
15 the like. Trisubstituted silyl group is substituted with C₁-C₆-alkyl, aryl, or ar-C₁-C₆-alkyl.

A particularly preferred precursor intermediate to an intermediate compound of formula VI is an intermediate compound of formula VII

20



VII

wherein m, n, p, g, X, Z, Y, D and R²⁰ are as defined above for formula VI.

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Among the several benefits and advantages of the present invention are the provision of compounds and compositions effective as inhibitors of matrix metalloproteinase activity, the provision of
5 such compounds and compositions that are effective for the inhibition of metalloproteinases implicated in diseases and disorders involving uncontrolled breakdown of connective tissue.

More particularly, a benefit of this
10 invention is the provision of a compound and composition effective for selectively inhibiting certain metalloproteinases, such as one or more of MMP-2, MMP-9 and MMP-13, associated with pathological conditions such as, for example, rheumatoid
15 arthritis, osteoarthritis, septic arthritis, corneal, epidermal or gastric ulceration, tumor metastasis, invasion or angiogenesis, periodontal disease, proteinuria, Alzheimer's Disease, coronary thrombosis and bone disease.

20 An advantage of the invention is the provision of compounds, compositions and methods effective for treating such pathological conditions by selective inhibition of a metalloproteinase such as MMP-2, MMP-9 or MMP-13 associated with such
25 conditions with minimal side effects resulting from inhibition of other metalloproteinases, such as MMP-1, whose activity is necessary or desirable for normal body function.

Yet another advantage of the invention is
30 the provision of a process for preparing such compounds.

Another benefit is the provision of a method for treating a pathological condition

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associated with abnormal matrix metalloproteinase activity.

A further advantage of the invention is the provision of a process for preparing such compositions.

Still further benefits and advantages of the invention will be apparent to the skilled worker from the disclosure that follows.

10 Detailed Description of the Invention

In accordance with the present invention, it has been discovered that certain aromatic sulfone hydroxamic acids (hydroxamates) are effective for inhibition of matrix metalloproteinases ("MMPs") believed to be associated with uncontrolled or otherwise pathological breakdown of connective tissue. In particular, it has been found that these certain aromatic sulfone hydroxamates are effective for inhibition of one or more enzymes such as MMP-2, MMP-9 and MMP-13, which can be particularly destructive to tissue if present or generated in abnormal quantities or concentrations, and thus exhibit a pathological activity. Included in that pathological activity is the assistance of tumors and tumor cells in the process of penetrating basement membrane, and developing a new or improved blood supply; i.e., angiogenesis.

Moreover, it has been discovered that these aromatic sulfone hydroxamates are selective in the inhibition of one or more of MMP-2, MMP-9 and MMP-13 without excessive inhibition of other collagenases essential to normal bodily function such as tissue turnover and repair. More particularly, it has been

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found that a contemplated aromatic sulfone hydroxamate of the invention, or a pharmaceutically acceptable salt thereof, is particularly active in inhibiting of one or more of MMP-2, MMP-9 and MMP-13 in an *in vitro* assay that is predictive of *in vivo* activity. In addition, while being selective for one or more of MMP-2, MMP-9 and MMP-13, a contemplated aromatic sulfone hydroxamate, or its salt, has a limited or minimal *in vitro* inhibitory effect on MMP-1.

There is thus a substantial difference in the activity of a compound used in a contemplated process toward one or more of MMP-2, MMP-9 and MMP-13 and MMP-1. This substantial difference is assayed using the *in vitro* inhibition assay discussed in the examples. A substantial difference in activity corresponds to a compound exhibiting an IC_{50} value against one or more of MMP-2, MMP-9 and MMP-13 that is about 0.1 times that of the compound against MMP-1, and more preferably 0.01 times that against MMP-1 and most preferably 0.001 times that against MMP-1, or more. Indeed, some compounds exhibit selectivity differences measured by IC_{50} values that exceed the bounds of the assay at the number 100,000-fold. These selectivities are illustrated in the Inhibition Tables hereinafter.

Put differently, a contemplated compound can inhibit the activity of MMP-2 compared to MMP-9 or MMP-13 and MMP-1. Similarly, a contemplated compound can inhibit the activity of MMP-13 and MMP-2, while exhibiting less inhibition against MMP-1 and MMP-9. In addition, a contemplated compound can inhibit the

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activity of a MMP enzyme, while having less of an effect on tumor necrosis factor release.

The advantages of the selectivity of a contemplated compound can be appreciated, without wishing to be bound by theory, by considering the therapeutic uses the compounds. For example, inhibition of MMP-1 is suggested to be undesirable due to its role as a housekeeping enzyme, helping to maintain normal connective tissue turnover and repair. Inhibition of MMP-1 can lead to toxicities or side effects such as joint or connective tissue deterioration and pain. On the other hand, MMP-13 has been suggested to be intimately involved in the destruction of joint components in diseases such as osteoarthritis. Thus, potent and selective inhibition of MMP-13 compared with inhibition MMP-1 is highly desirable because a MMP-13 inhibitor can have a positive effect on disease progression in a patient in addition to having an anti-inflammatory effect.

Inhibition of MMP-2 and MMP-9 can be desirable for inhibition of tumor growth, metastasis, invasion and/or angiogenesis. A profile of selective inhibition of MMP-2 and MMP-9 relative to MMP-1 can provide a therapeutic advantage.

Yet another advantage of a contemplated compound is the selectivity with respect to tumor necrosis factor release and/or tumor necrosis factor receptor release that provides the physician with another factor to help select the best drug for a particular patient. While not wishing to be bound by theory, it is believed that there are several factors to this type of selectivity to be considered.

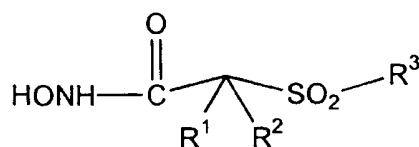
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The first is that presence of tumor necrosis factor can be desirable for the control of cancer in the organism, so long as TNF is not present in a toxic excess. Thus, uncontrolled inhibition of release of TNF can be counterproductive and actually can be considered an adverse side effect even in cancer patients. In addition, selectivity with respect to inhibition of the release of the tumor necrosis factor receptor can also be desirable. The presence of that receptor can be desirable for maintaining a controlled tumor necrosis level in the mammal by binding excess TNF.

A contemplated selective MMP inhibitor compound useful in a contemplated process can be administered to by various routes and provide adequate therapeutic blood levels of enzymatically active inhibitor. A compound can be administered, for example, by the oral (IG, PO) or intravenous (IV) routes. Oral administration is advantageous if the patient is ambulatory, not hospitalized, physically able and sufficiently responsible to take drug at the required intervals. This is true even if the person is being treated with more than one drug for one or more diseases. On the other hand, IV drug administration is an advantage in a hospital setting wherein the dose and thus the blood levels can well controlled. A contemplated inhibitor can also be formulated for IM administration if desired. This route of administration can be desirable for the administration of prodrugs or regular drug delivery to patients that are either physically weak or have a poor compliance record or require constant drug blood levels.

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Thus, in one embodiment, the present invention is directed to a treatment process that comprises administering a contemplated aromatic sulfone hydroxamic acid metalloprotease inhibitor, or a
5 pharmaceutically acceptable salt thereof, in an effective amount to a host mammal having a condition associated with pathological matrix metalloprotease activity. A contemplated aromatic sulfone hydroxamate inhibitor compound useful in such a
10 process inhibits the activity of one or more of MMP-2, MMP-9 and MMP-13, and exhibits substantially less inhibitory activity against at least MMP-1 in the in vitro assay noted above and discussed in detail hereinbelow. An aromatic sulfone hydroxamate
15 inhibitor compound for use in a contemplated process corresponds in structure to formula I, below:



I

wherein

20

In one embodiment, R^1 and R^2 are both hydrido. In another embodiment, R^1 and R^2 together with the atoms to which they are bonded form a 5- to 8-membered ring containing one, two or three
25 heteroatoms in the ring that are oxygen, sulfur or nitrogen.

It is preferred that R^1 and R^2 together with the atoms to which they are bonded form a five- to eight-

membered ring that contains one or two heteroatoms in the ring, although R^1 and R^2 together with the atoms to which they are bonded form a 5- to 8-membered ring containing one, two or three heteroatoms. The
5 heterocyclic ring can itself also be substituted with up to six C_1 - C_6 -alkyl groups or groups that comprise a another 5- to 8-membered carbocyclic or heterocyclic ring, an amino group, or contain one or two oxo (carbonyl) groups.

10 R^3 in formula I is an optionally substituted aryl or optionally substituted heteroaryl radical. That R^3 radical is selected from the group consisting of an aryl, heteroaryl, aralkyl, heteroaralkyl, aralkoxy, heteroaralkoxy, aralkoxyalkyl,
15 aryloxyalkyl, aralkanoylalkyl, arylcarbonylalkyl, aralkylaryl, aryloxyalkylaryl, aralkoxyaryl, arylazoaryl, arylhydrazinoaryl, alkylthioaryl, arylthioalkyl, alkylthioaralkyl, aralkylthioalkyl, an aralkylthioaryl radical, the sulfoxide or sulfone of
20 any of the thio substituents, and a fused ring structure comprising two or more 5- or 6-membered rings selected from the group consisting of aryl, heteroaryl, carbocyclic and heterocyclic.

The substituent of which R^3 is comprised itself
25 is unsubstituted or substituted with one or more substituents independently selected from the group consisting of a cyano, perfluoroalkyl, trifluoromethylalkyl, hydroxy, halo, alkyl, alkoxy, nitro, thiol, hydroxycarbonyl, aryloxy, arylthio,
30 aralkyl, aryl, heteroaryloxy, heteroarylthio, heteroaralkyl, cycloalkyl, heterocyclooxy, heterocyclothio, heterocycloamino, cycloalkyloxy,

cycloalkylthio, heteroaralkoxy, heteroaralkylthio,
aralkoxy, aralkylthio, aralkylamino, heterocyclo,
heteroaryl, arylazo, hydroxycarbonylalkoxy,
alkoxycarbonylalkoxy, alkanoyl, arylcarbonyl,
5 aralkanoyl, alkanoyloxy, aralkanoyloxy, hydroxyalkyl,
hydroxyalkoxy, alkylthio, alkoxyalkylthio,
alkoxycarbonyl, aryloxyalkoxyaryl,
arylthioalkylthioaryl, aryloxyalkylthioaryl,
arylthioalkoxyaryl, hydroxycarbonylalkoxy,
10 hydroxycarbonylalkylthio, alkoxyalkoxyalkoxy,
alkoxyalkoxyalkylthio, amino,
wherein the amino nitrogen is (i) unsubstituted,
or (ii) substituted with one or two substituents
that are independently selected from the group
15 consisting of an alkyl, aryl, heteroaryl,
aralkyl, cycloalkyl, aralkoxycarbonyl,
alkoxycarbonyl, arylcarbonyl, aralkanoyl,
heteroarylcarbonyl, heteroaralkanoyl and an
alkanoyl group, or (iii) wherein the amino
20 nitrogen and two substituents attached thereto
form a 5- to 8-membered heterocyclo or
heteroaryl ring containing zero to two
additional heteroatoms that are nitrogen, oxygen
or sulfur and which ring itself is (a)
25 unsubstituted or (b) substituted with one or two
groups independently selected from the group
consisting of an aryl, alkyl, heteroaryl,
aralkyl, heteroaralkyl, hydroxy, alkoxy,
alkanoyl, cycloalkyl, heterocycloalkyl,
30 alkoxyalkoxy, hydroxyalkyl, trifluoromethyl,
benzofused heterocycloalkyl, hydroxyalkoxyalkyl,
aralkoxycarbonyl, hydroxycarbonyl,
aryloxyalkoxy, benzofused heterocycloalkoxy,

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benzofused cycloalkylcarbonyl, heterocyclo-alkylcarbonyl, and a cycloalkylcarbonyl group, carbonylamino

wherein the carboxamido nitrogen is (i) unsubstituted, or (ii) is the reacted amine of an amino acid, or (iii) substituted with one or two radicals selected from the group consisting of an alkyl, hydroxyalkyl, hydroxyheteroaralkyl, cycloalkyl, aralkyl, trifluoromethylalkyl, heterocycloalkyl, benzofused heterocycloalkyl, benzofused heterocycloalkyl, benzofused cycloalkyl, and an N,N-dialkylsubstituted alkylamino-alkyl group, or (iv) the carboxamido nitrogen and two substituents bonded thereto together form a 5- to 8-membered heterocyclo, heteroaryl or benzofused heterocycloalkyl ring that is itself unsubstituted or substituted with one or two radicals independently selected from the group consisting of an alkyl, alkoxy carbonyl, nitro, heterocycloalkyl, hydroxy, hydroxycarbonyl, aryl, aralkyl, heteroaralkyl and an amino group,

wherein the amino nitrogen is (i) unsubstituted, or (ii) substituted with one or two substituents that are independently selected from the group consisting of alkyl, aryl, and heteroaryl, or (iii) wherein the amino nitrogen and two substituents attached thereto form a 5- to 8-membered heterocyclo or heteroaryl ring, and an aminoalkyl group

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wherein the aminoalkyl nitrogen is (i) unsubstituted, or (ii) substituted with one or two substituents independently selected from the group consisting of an alkyl, aryl, aralkyl, cycloalkyl, aralkoxycarbonyl, alkoxycarbonyl, and an alkanoyl group, or (iii) wherein the aminoalkyl nitrogen and two substituents attached thereto form a 5- to 8-membered heterocyclo or heteroaryl ring. A compound of formula I can also be used in the form of a pharmaceutically acceptable salt.

The R^3 radical has a length that is greater than that of a pentyl group [a $-(CH_2)_4CH_3$ chain], and is more preferably greater than about the length of a hexyl group [a $-(CH_2)_5CH_3$ chain]. A R^3 group has a length that is less than that of an icosyl group [eicosyl; a $-(CH_2)_{19}CH_3$ chain], and more preferably, a length that is less than that of a stearyl group [a $-(CH_2)_{17}CH_3$ chain]. When rotated about an axis drawn through the SO_2 -bonded 1-position and the substituent-bonded 4-position of a 6-membered ring or the SO_2 -bonded 1-position and substituent-bonded 3- or 4-position of a 5-membered ring, a contemplated R^3 radical defines a three-dimensional volume whose widest dimension has the width of about one furanyl ring to about two phenyl rings in a direction transverse to that axis to rotation.

Where the SO_2 -linked R^3 radical is 4-phenoxyphenyl for purposes of illustration, a contemplated compound can be viewed as a phenoxyphenylsulfone derivative of the desired 5- to

8-membered ring N-hydroxycarboxamide. Exemplary compounds can therefore be named:

- N-hydroxy-1-methyl-[4-(phenoxyphenylsulfonyl)]-4-piperidinecarboxamide,
- 5 N-hydroxy-[4-(phenoxyphenylsulfonyl)]tetrahydro-2H-pyran-4-carboxamide,
- N-hydroxy-1-methyl-[2,6-dioxo-4-(phenoxyphenylsulfonyl)]-4-piperidinecarboxamide,
- N-hydroxy-2,2-dimethyl-[5-(phenoxyphenylsulfonyl)]-1,3-dioxane-5-carboxamide,
- 10 N-hydroxy-1,2-dimethyl-6-oxo-[4-(phenoxyphenylsulfonyl)]-4-piperidinecarboxamide,
- N-hydroxy-2,2,6,6-tetramethyl-[4-(phenoxyphenylsulfonyl)]-4-piperidinecarboxamide,
- 15 N-hydroxy-1,3-dimethyl-[5-(phenoxyphenylsulfonyl)]-hexahydro-5-pyrimidinecarboxamide,
- 2-amino-N-hydroxy-[5-(phenoxyphenylsulfonyl)]-1,4,5,6-tetrahydro-5-pyrimidinecarboxamide,
- N-hydroxy-1,1-dioxo-[4-(phenoxyphenylsulfonyl)]-1(λ 6),2,6-thiadizinane-4-carboxamide,
- 20 N-hydroxy-2-oxo-[5-(phenoxyphenylsulfonyl)]-hexahydro-5-pyrimidinecarboxamide,
- N-hydroxy-[2-(phenoxyphenylsulfonyl)]tetrahydro-2-furancarboxamide,
- 25 N-hydroxy-1-methyl-[2-(phenoxyphenylsulfonyl)]-2-pyrrolidinecarboxamide,
- N-hydroxy-2-methyl-[4-(phenoxyphenylsulfonyl)]-4-piperidinecarboxamide,
- N-hydroxy-[3-(phenoxyphenylsulfonyl)]-8-azabicyclo[3.2.1]octane-3-carboxamide,
- 30 N-hydroxy-1,1-dioxo-[4-(phenoxyphenylsulfonyl)]-hexahydro-1(λ 6)-thiopyran-4-carboxamide,

- 40 -

N-hydroxy- [3- (phenoxyphenylsulfonyl)] tetrahydro-
3-furancarboxamide,

N-hydroxy- [3- (phenoxyphenylsulfonyl)] -3-
pyrrolidinecarboxamide,

5 N-hydroxy-4- [[4- (phenylthio)phenyl] sulfonyl] -1-
(2-propynyl) -4-piperidinecarboxamide,
monohydrochloride,

N-hydroxy-4- [[4- (phenylthio)phenyl] sulfonyl] -1-
(2-propynyl) -4-piperidinecarboxamide,
10 monomethanesulfonate,

tetrahydro-N-hydroxy-4- [[4- [4-
[(trifluoromethyl)phenoxy]phenyl] -sulfonyl] -2H-pyran-
4-carboxamide,

N-hydroxy-1- (4-pyridinylmethyl) -4- [[4- [4-
15 (trifluoromethyl)phenoxy]phenyl] -sulfonyl] -4-
piperidinecarboxamide, hydrochloride,

N-hydroxy-1- (3-pyridinylmethyl) -4- [[4- [4-
trifluoromethyl)phenoxy]phenyl] -sulfonyl] -4-
piperidinecarboxamide, dihydrochloride,

20 N-hydroxy-1- (2-pyridinylmethyl) -4- [[4- [4-
(trifluoromethyl)phenoxy]phenyl] -sulfonyl] -4-
piperidinecarboxamide, dihydrochloride,

hydroxy-1- (3-pyridinylmethyl) -4- [[4- [4-
(trifluoromethoxy)phenoxy]phenyl] -sulfonyl] -4-
25 piperidinecarboxamide, dihydrochloride,

N-hydroxy-1- (2-methoxyethyl) -4- [[4- [4-
(trifluoromethoxy)phenoxy]phenyl] sulfonyl] -4-
piperidinecarboxamide, monohydrochloride,

N-hydroxy-1- (2-methoxyethyl) -4- [[4- [4-
30 (trifluoromethyl)phenoxy]phenyl] sulfonyl] -4-
piperidinecarboxamide, monohydrochloride,

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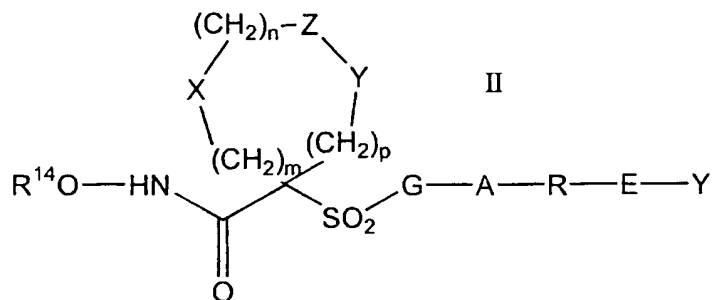
N-hydroxy-1-(2-methoxyethyl)-4-[[4-[4-
 [(trifluoromethyl)thio]phenoxy]phenyl]sulfonyl]-4-
 piperidinecarboxamide, monohydrochloride,

1-cyclopropyl-N-hydroxy-4-[[4-[4-(trifluoro-
 5 methyl)phenoxy]phenyl]sulfonyl]-4-piperidine-
 carboxamide, monohydrochloride, and the like.

Several exemplary R^1 and R^2 groups that together
 form a contemplated heterocyclic ring are shown in
 the Tables that follow hereinafter, as well as in the
 10 descriptions of those 5- to 8-membered rings and the
 specific Examples, as are several contemplated
 aromatic sulfone hydroxamic acid compounds.

In more preferred practice, R^1 and R^2 of formula
 I together with the atom to which they are bonded
 15 form a 5- to 8-membered ring that contains one, two
 or three heteroatoms. Most preferably, that ring is
 a 6-membered ring that contains one heteroatom
 located at the 4-position relative to the position at
 which the SO_2 group is bonded. Other preferred
 20 compounds for use in a contemplated process
 correspond in structure to one or more of formulas
 II, III, IV or V, which are discussed hereinafter.

In one embodiment, a preferred compound used in
 a contemplated process has a structure that
 25 corresponds to formula II, below:



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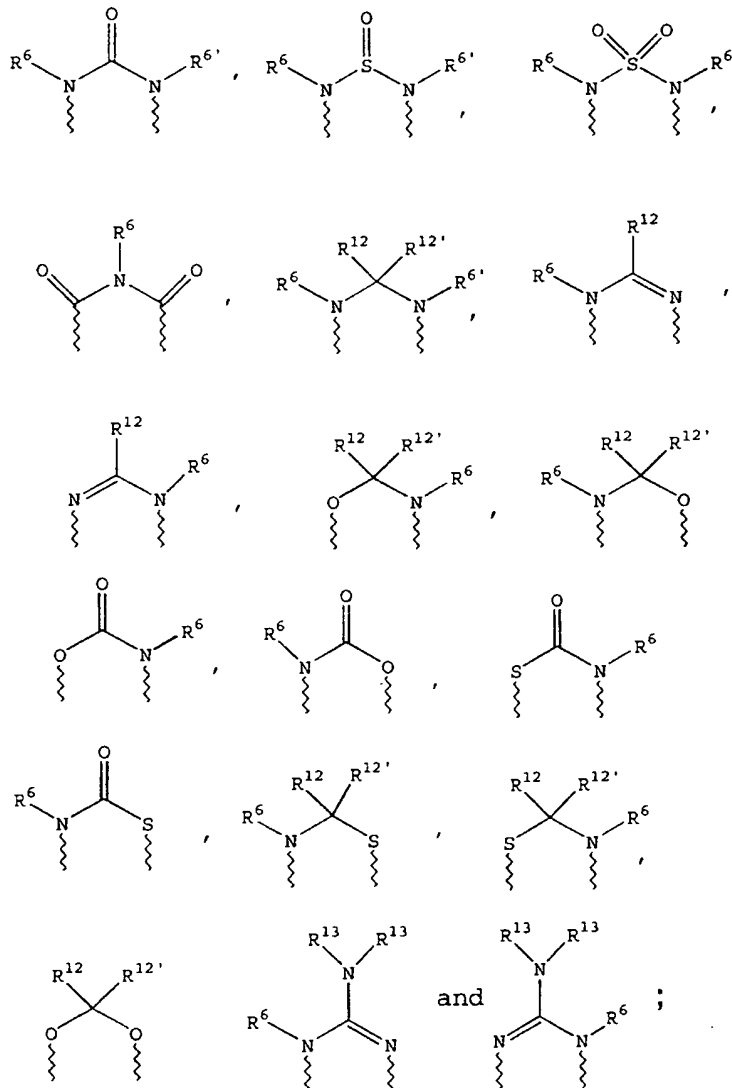
wherein

- R^{14} is hydrido, a pharmaceutically acceptable cation or $C(W)R^{15}$ where W is O or S and
- 5 R^{15} is selected from the group consisting of an C_1 - C_6 -alkyl, aryl, C_1 - C_6 -alkoxy, heteroaryl- C_1 - C_6 -alkyl, C_3 - C_8 -cycloalkyl- C_1 - C_6 -alkyl, aryloxy, ar- C_1 - C_6 -alkoxy, ar- C_1 - C_6 -alkyl, heteroaryl and amino C_1 - C_6 -alkyl group wherein the aminoalkyl nitrogen is (i)
- 10 unsubstituted or (ii) substituted with one or two substituents independently selected from the group consisting of an C_1 - C_6 -alkyl, aryl, ar- C_1 - C_6 -alkyl, C_3 - C_8 -cycloalkyl- C_1 - C_6 -alkyl, ar- C_1 - C_6 -alkoxycarbonyl, C_1 - C_6 -alkoxycarbonyl, and C_1 - C_6 -alkanoyl radical, or (iii) wherein the amino C_1 - C_6 -alkyl nitrogen and two substituents attached thereto
- 15 form a 5- to 8-membered heterocyclo or heteroaryl ring;
- m is zero, 1 or 2;
- 20 n is zero, 1 or 2;
- p is zero, 1 or 2;
- the sum of $m + n + p = 1, 2, 3$ or 4;
- (a) one of X, Y and Z is selected from the group consisting of $C(O)$, NR^6 , O, S, $S(O)$, $S(O)_2$ and
- 25 $NS(O)_2R^7$, and the remaining two of X, Y and Z are CR^8R^9 , and $CR^{10}R^{11}$, or
- (b) X and Z or Z and Y together constitute a moiety that is selected from the group consisting of $NR^6C(O)$, $NR^6S(O)$, $NR^6S(O)_2$, NR^6S , NR^6O , SS, NR^6NR^6

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and OC(O), with the remaining one of X, Y and Z being CR⁸R⁹, or

(c) n is zero and X, Y and Z together constitute a moiety selected from the group
5 consisting of



wherein wavy lines are bonds to the atoms of the
10 depicted ring;

R^6 and $R^{6'}$ are independently selected from the group consisting of hydrido, C_1 - C_6 -alkanoyl, C_6 -aryl- C_1 - C_6 -alkyl, aroyl, bis(C_1 - C_6 -alkoxy- C_1 - C_6 -alkyl)- C_1 - C_6 -alkyl, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -perfluoroalkyl, C_1 - C_6 -trifluoromethylalkyl, C_1 - C_6 -perfluoroalkoxy- C_1 - C_6 -alkyl, C_1 - C_6 -alkoxy- C_1 - C_6 -alkyl, C_3 - C_6 -cycloalkyl, C_3 - C_8 -heterocycloalkyl, C_3 - C_8 -heterocycloalkylcarbonyl, C_6 -aryl, C_5 - C_6 -heterocyclo, C_5 - C_6 -heteroaryl, C_3 - C_8 -cycloalkyl- C_1 - C_6 -alkyl, C_6 -aryloxy- C_1 - C_6 -alkyl, heteroaryloxy- C_1 - C_6 -alkyl, heteroaryl- C_1 - C_6 -alkoxy- C_1 - C_6 -alkyl, heteroarylthio- C_1 - C_6 -alkyl, C_6 -arylsulfonyl, C_1 - C_6 -alkylsulfonyl, C_5 - C_6 -heteroarylsulfonyl, carboxy- C_1 - C_6 -alkyl, C_1 - C_4 -alkoxycarbonyl- C_1 - C_6 -alkyl, aminocarbonyl, C_1 - C_6 -alkyliminocarbonyl, C_6 -aryliminocarbonyl, C_5 - C_6 -heterocycloiminocarbonyl, C_6 -arylthio- C_1 - C_6 -alkyl, C_1 - C_6 -alkylthio- C_1 - C_6 -alkyl, C_6 -arylthio- C_3 - C_6 -alkenyl, C_1 - C_4 -alkylthio- C_3 - C_6 -alkenyl, C_5 - C_6 -heteroaryl- C_1 - C_6 -alkyl, halo- C_1 - C_6 -alkanoyl, hydroxy- C_1 - C_6 -alkanoyl, thiol- C_1 - C_6 -alkanoyl, C_3 - C_6 -alkenyl, C_3 - C_6 -alkynyl, C_1 - C_4 -alkoxy- C_1 - C_4 -alkyl, C_1 - C_5 -alkoxycarbonyl, aryloxycarbonyl, NR^8R^9 - C_1 - C_5 -alkylcarbonyl, hydroxy- C_1 - C_5 -alkyl, an aminocarbonyl wherein the aminocarbonyl nitrogen is
 (i) unsubstituted or (ii) substituted with one or two radicals independently selected from the group consisting of C_1 - C_6 -alkyl, ar- C_1 - C_6 -alkyl, C_3 - C_8 -cycloalkyl and a C_1 - C_6 -alkanoyl group,

hydroxyaminocarbonyl, an aminosulfonyl group wherein the aminosulfonyl nitrogen is (i) unsubstituted or (ii) substituted with one or two radicals independently selected from the group consisting of
5 C₁-C₆-alkyl, ar-C₁-C₆-alkyl, C₃-C₈-cycloalkyl and a C₁-C₆-alkanoyl group, an amino-C₁-C₆-alkylsulfonyl group wherein the amino-C₁-C₆-alkylsulfonyl nitrogen is (i) unsubstituted or (ii) substituted with one or two radicals independently selected from the group
10 consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, C₃-C₈-cycloalkyl and a C₁-C₆-alkanoyl group and an amino-C₁-C₆-alkyl group wherein the aminoalkyl nitrogen is (i) unsubstituted or (ii) substituted with one or two radicals independently selected from the group
15 consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, C₃-C₈-cycloalkyl and a C₁-C₆-alkanoyl group;

R⁷ is selected from the group consisting of a benzyl, phenyl, C₁-C₆-alkyl, C₃-C₆-alkynyl, C₃-C₆-alkenyl and a C₁-C₆-hydroxyalkyl group;

20 R⁸ and R⁹ and R¹⁰ and R¹¹ are independently selected from the group consisting of a hydrido, hydroxy, C₁-C₆-alkyl, aryl, ar-C₁-C₆-alkyl, heteroaryl, heteroar-C₁-C₆-alkyl, C₂-C₆-alkynyl, C₂-C₆-alkenyl, thiol-C₁-C₆-alkyl, C₁-C₆-alkylthio-C₁-C₆-
25 alkyl cycloalkyl, cycloalkyl-C₁-C₆-alkyl, heterocycloalkyl-C₁-C₆-alkyl, C₁-C₆-alkoxy-C₁-C₆-alkyl, aralkoxy-C₁-C₆-alkyl, C₁-C₆-alkoxy-C₁-C₆-alkoxy-C₁-C₆-alkyl, hydroxy-C₁-C₆-alkyl, hydroxycarbonyl-C₁-C₆-alkyl, hydroxycarbonylar-C₁-C₆-

alkyl, aminocarbonyl-C₁-C₆-alkyl, aryloxy-C₁-C₆-alkyl, heteroaryloxy-C₁-C₆-alkyl, arylthio-C₁-C₆-alkyl, heteroarylthio-C₁-C₆-alkyl, the sulfoxide or sulfone of any said thio substituents, perfluoro-C₁-C₆-alkyl, trifluoromethyl-C₁-C₆-alkyl, halo-C₁-C₆-alkyl, alkoxycarbonylamino-C₁-C₆-alkyl and an amino-C₁-C₆-alkyl group wherein the aminoalkyl nitrogen is (i) unsubstituted or (ii) substituted with one or two radicals independently selected from the group consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, cycloalkyl and C₁-C₆-alkanoyl, or wherein R⁸ and R⁹ or R¹⁰ and R¹¹ and the carbon to which they are bonded form a carbonyl group, or wherein R⁸ and R⁹ or R¹⁰ and R¹¹, or R⁸ and R¹⁰ together with the atoms to which they are bonded form a 5- to 8-membered carbocyclic ring, or a 5- to 8-membered heterocyclic ring containing one or two heteroatoms that are nitrogen, oxygen, or sulfur, with the proviso that only one of R⁸ and R⁹ or R¹⁰ and R¹¹ is hydroxy;

R¹² and R^{12'} are independently selected from the group consisting of a hydrido, C₁-C₆-alkyl, aryl, ar-C₁-C₆-alkyl, heteroaryl, heteroaralkyl, C₂-C₆-alkynyl, C₂-C₆-alkenyl, thiol-C₁-C₆-alkyl, cycloalkyl, cycloalkyl-C₁-C₆-alkyl, heterocycloalkyl-C₁-C₆-alkyl, C₁-C₆-alkoxy-C₁-C₆-alkyl, aryloxy-C₁-C₆-alkyl, amino-C₁-C₆-alkyl, C₁-C₆-alkoxy-C₁-C₆-alkoxy-C₁-C₆-alkyl, hydroxy-C₁-C₆-alkyl, hydroxycarbonyl-C₁-C₆-alkyl, hydroxycarbonylar-C₁-C₆-alkyl,

aminocarbonyl-C₁-C₆-alkyl, aryloxy-C₁-C₆-alkyl,
heteroaryloxy-C₁-C₆-alkyl, C₁-C₆-alkylthio-C₁-C₆-
alkyl, arylthio-C₁-C₆-alkyl, heteroarylthio-C₁-C₆-
alkyl, the sulfoxide or sulfone of any said thio
5 substituents, perfluoro-C₁-C₆-alkyl, trifluoromethyl-
C₁-C₆-alkyl, halo-C₁-C₆-alkyl, alkoxycarbonylamino-
C₁-C₆-alkyl and an amino-C₁-C₆-alkyl group wherein
the aminoalkyl nitrogen is (i) unsubstituted or (ii)
substituted with one or two radicals independently
10 selected from the group consisting of C₁-C₆-alkyl,
ar-C₁-C₆-alkyl, cycloalkyl and C₁-C₆-alkanoyl;

R¹³ is selected from the group consisting of a
hydrido, benzyl, phenyl, C₁-C₆-alkyl, C₂-C₆-alkynyl,
C₂-C₆-alkenyl and a C₁-C₆-hydroxyalkyl group; and

15 G-A-R-E-Y is a substituent that preferably has a
length greater than that of a pentyl group, and more
preferably has a length greater than that of a hexyl
group. The substituent G-A-R-E-Y preferably has a
length that is less than that of an icosyl group, and
20 is more preferably less than that of a stearyl group.
In this substituent:

G is an aryl or heteroaryl group;

A is selected from the group consisting of

- 25 (1) -O-;
(2) -S-;
(3) -NR¹⁷-;
(4) -CO-N(R¹⁷) or -N(R¹⁷)-CO-, wherein R¹⁷
is hydrogen, C₁-C₄-alkyl, or phenyl;
(5) -CO-O- or -O-CO-;

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- (6) -O-CO-O-;
- (7) -HC=CH-;
- (8) -NH-CO-NH-;
- (9) -C≡C-;
- 5 (10) -NH-CO-O- or -O-CO-NH-;
- (11) -N=N-;
- (12) -NH-NH-; and
- (13) -CS-N(R¹⁸)- or -N(R¹⁸)-CS-, wherein
 R¹⁸ is hydrogen C₁-C₄-alkyl, or
 10 phenyl; or
- (14) A is absent and G is bonded directly
 to R;

R is a moiety selected from the group consisting
 of alkyl, alkoxyalkyl, aryl, heteroaryl, cycloalkyl,
 15 heterocycloalkyl, aralkyl, heteroaralkyl,
 heterocycloalkylalkyl, cycloalkylalkyl,
 cycloalkoxyalkyl, heterocycloalkoxyalkyl,
 aryloxyalkyl, heteroaryloxyalkyl, arylthioalkyl,
 heteroarylthioalkyl, cycloalkylthioalkyl, and a
 20 heterocycloalkylthioalkyl group wherein the aryl or
 heteroaryl or cycloalkyl or heterocycloalkyl
 substituent is (i) unsubstituted or (ii) substituted
 with one or two radicals selected from the group
 consisting of a halo, alkyl, perfluoroalkyl,
 25 perfluoroalkoxy, perfluoroalkylthio,
 trifluoromethylalkyl, amino, alkoxycarbonylalkyl,
 alkoxy, C₁-C₂-alkylene-dioxy, hydroxycarbonylalkyl,
 hydroxycarbonylalkylamino, nitro, hydroxy,
 hydroxyalkyl, alkanoylamino, and a alkoxycarbonyl

group, and R is other than alkyl or alkoxyalkyl when A is -O- or -S-;

E is selected from the group consisting of

- 5 (1) -CO(R¹⁹)- or -(R¹⁹)CO-, wherein R¹⁹ is a heterocycloalkyl, or a cycloalkyl group;
- (2) -CONH- or -HNCO-; and
- (3) -CO-;
- (4) -SO₂-R¹⁹- or -R¹⁹-SO₂-;
- 10 (5) -SO₂-;
- (6) -NH-SO₂- or -SO₂-NH-; or
- (7) E is absent and R is bonded directly to Y; and

Y is absent or is selected from the group

15 consisting of a hydrido, alkyl, alkoxy, haloalkyl, aryl, aralkyl, cycloalkyl, heteroaryl, hydroxy, aryloxy, aralkoxy, heteroaryloxy, heteroaralkyl, perfluoroalkoxy, perfluoroalkylthio, trifluoromethylalkyl, alkenyl, heterocycloalkyl,

20 cycloalkyl, trifluoromethyl, alkoxy carbonyl, and an aminoalkyl group, wherein the aryl or heteroaryl or heterocycloalkyl group is (i) unsubstituted or (ii) substituted with one or two radicals independently selected from the group consisting of an alkanoyl,

25 halo, nitro, aralkyl, aryl, alkoxy, and an amino group wherein the amino nitrogen is (i) unsubstituted or (ii) substituted with one or two groups independently selected from hydrido, alkyl, and an aralkyl group.

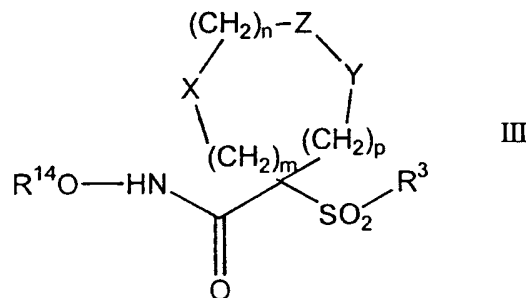
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The substituent -G-A-R-E-Y preferably contains two to four carbocyclic or heterocyclic rings, including the aryl or heteroaryl group, G. More preferably, each of those rings is 6-membered.

- 5 Additional separate preferences for a compound of formula II include: (a) that A is -O- or -S-, (b) R is an aryl, heteroaryl, cycloalkyl or heterocycloalkyl group, (c) E is absent, and (d) Y is
 10 alkyl, alkoxy, perfluoroalkoxy and a perfluoroalkylthio group.

A more preferred compound for use in a contemplated process has a structure that corresponds to formula III, below:

15



- wherein R³ is a single-ringed aryl or heteroaryl group that is 5- or 6-membered, and is
 20 itself substituted at its own 4-position when a 6-membered ring and at its own 3- or 4-position when a 5-membered ring with a substituent selected from the group consisting of a thiophenoxy, 4-chloro-
 phenoxy, 3-chlorophenoxy, 4-methoxyphenoxy, 3-
 25 benzodioxol-5-yloxy, 3,4-dimethylphenoxy, 4-fluoro-
 phenoxy, 4-fluorothiophenoxy, phenoxy, 4-trifluoro-

methoxyphenoxy, 4-trifluoromethylphenoxy, 4-(trifluoromethylthio)phenoxy, 4-(trifluoromethylthio)thiophenoxy, 4-chloro-3-fluorophenoxy, 4-isopropoxyphenoxy, 4-isopropylphenoxy, (2-methyl-1,3-benzothiazol-5-yl)oxy, 4-(1H-imidazol-1-yl)phenoxy, 4-chloro-3-methylphenoxy, 3-methyl-phenoxy, 4-ethoxyphenoxy, 3,4-difluorophenoxy, 4-chloro-3-methylphenoxy, 4-fluoro-3-chlorophenoxy, 4-(1H-1,2,4-triazol-1-yl)phenoxy, 3,5-difluorophenoxy, 3,4-dichlorophenoxy, 4-cyclopentylphenoxy, 4-bromo-3-methylphenoxy, 4-bromophenoxy, 4-methylthiophenoxy, 4-phenylphenoxy, 4-benzylphenoxy, 6-quinolinyloxy, 4-amino-3-methylphenoxy, 3-methoxyphenoxy, 5,6,7,8-tetrahydro-2-naphthalenyloxy, 3-hydroxymethylphenoxy, and a 4-benzyloxyphenoxy group;

R^{14} is hydrido, a pharmaceutically acceptable cation or $C(W)R^{15}$ where W is O or S and R^{15} is selected from the group consisting of an C_1 - C_6 -alkyl, aryl, C_1 - C_6 -alkoxy, heteroaryl- C_1 - C_6 -alkyl, C_3 - C_8 -cycloalkyl- C_1 - C_6 -alkyl, aryloxy, ar- C_1 - C_6 -alkoxy, ar- C_1 - C_6 -alkyl, heteroaryl and amino C_1 - C_6 -alkyl group wherein the aminoalkyl nitrogen is (i) unsubstituted or (ii) substituted with one or two substituents independently selected from the group consisting of an C_1 - C_6 -alkyl, aryl, ar- C_1 - C_6 -alkyl, C_3 - C_8 -cycloalkyl- C_1 - C_6 -alkyl, ar- C_1 - C_6 -alkoxycarbonyl, C_1 - C_6 -alkoxycarbonyl, and a C_1 - C_6 -alkanoyl radical, or (iii) wherein the amino C_1 - C_6 -alkyl nitrogen and two substituents attached thereto

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form a 5- to 8-membered heterocyclo or heteroaryl ring;

m is zero, 1 or 2;

n is zero, 1 or 2;

5 p is zero, 1 or 2;

the sum of $m + n + p = 1, 2, 3$ or 4;

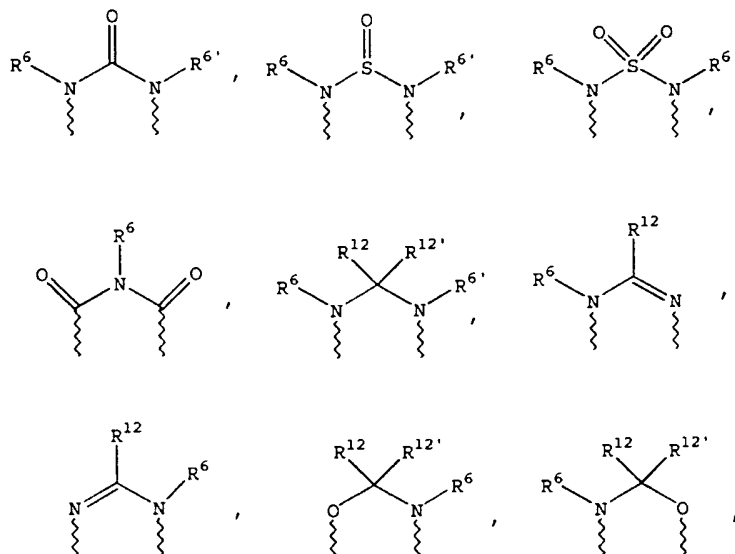
(a) one of X, Y and Z is selected from the group consisting of $C(O)$, NR^6 , O, S, $S(O)$, $S(O)_2$ and $NS(O)_2R^7$, and the remaining two of X, Y and Z are

10 CR^8R^9 , and $CR^{10}R^{11}$, or

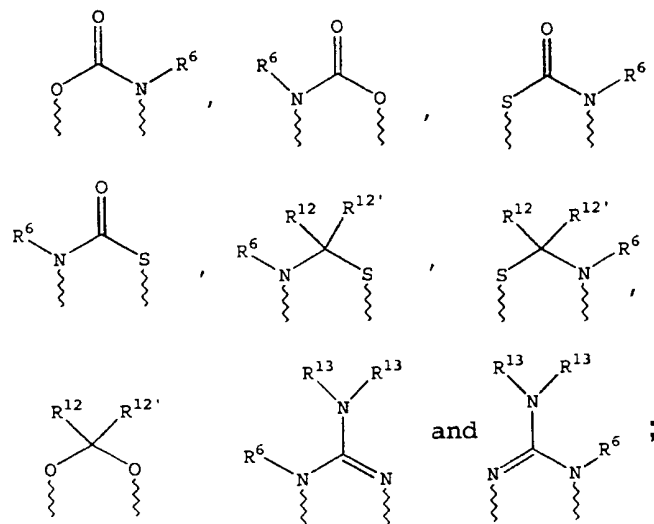
(b) X and Z or Z and Y together constitute a moiety that is selected from the group consisting of $NR^6C(O)$, $NR^6S(O)$, $NR^6S(O)_2$, NR^6S , NR^6O , SS, NR^6NR^6 and $OC(O)$, with the remaining one of X, Y and Z being

15 CR^8R^9 , or

(c) n is zero and X, Y and Z together constitute a moiety selected from the group consisting of



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wherein wavy lines are bonds to the atoms of the depicted ring;

- 5 R⁶ and R^{6'} are independently selected from the group consisting of hydrido, C₁-C₆-alkanoyl, C₆-aryl-C₁-C₆-alkyl, aroyl, bis(C₁-C₆-alkoxy-C₁-C₆-alkyl)-C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₁-C₆-perfluoroalkyl, C₁-C₆-trifluoromethylalkyl, C₁-C₆-perfluoroalkoxy-C₁-C₆-alkyl, C₁-C₆-alkoxy-C₁-C₆-alkyl, C₃-C₆-cycloalkyl, C₃-C₈-heterocycloalkyl, C₃-C₈-heterocycloalkylcarbonyl, C₆-aryl, C₅-C₆-heterocyclo, C₅-C₆-heteroaryl, C₃-C₈-cycloalkyl-C₁-C₆-alkyl, C₆-aryloxy-C₁-C₆-alkyl, heteroaryloxy-C₁-C₆-alkyl, heteroaryl-C₁-C₆-alkoxy-C₁-C₆-alkyl, heteroarylthio-C₁-C₆-alkyl, C₆-arylsulfonyl, C₁-C₆-alkylsulfonyl, C₅-C₆-heteroarylsulfonyl, carboxy-C₁-C₆-alkyl, C₁-C₄-alkoxycarbonyl-C₁-C₆-alkyl, aminocarbonyl, C₁-C₆-alkyliminocarbonyl, C₆-
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aryliminocarbonyl, C₅-C₆-heterocycloiminocarbonyl, C₆-arylthio-C₁-C₆-alkyl, C₁-C₆-alkylthio-C₁-C₆-alkyl, C₆-arylthio-C₃-C₆-alkenyl, C₁-C₄-alkylthio-C₃-C₆-alkenyl, C₅-C₆-heteroaryl-C₁-C₆-alkyl, halo-C₁-C₆-alkanoyl, hydroxy-C₁-C₆-alkanoyl, thiol-C₁-C₆-alkanoyl, C₃-C₆-alkenyl, C₃-C₆-alkynyl, C₁-C₄-alkoxy-C₁-C₄-alkyl, C₁-C₅-alkoxycarbonyl, aryloxycarbonyl, NR⁸R⁹-C₁-C₅-alkylcarbonyl, hydroxy-C₁-C₅-alkyl, an aminocarbonyl wherein the aminocarbonyl nitrogen is

10 (i) unsubstituted or (ii) substituted with one or two radicals independently selected from the group consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, C₃-C₈-cycloalkyl and a C₁-C₆-alkanoyl group,

hydroxyaminocarbonyl, an aminosulfonyl group wherein

15 the aminosulfonyl nitrogen is (i) unsubstituted or (ii) substituted with one or two radicals independently selected from the group consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, C₃-C₈-cycloalkyl and a C₁-C₆-alkanoyl group, an amino-C₁-C₆-alkylsulfonyl

20 group wherein the amino-C₁-C₆-alkylsulfonyl nitrogen is (i) unsubstituted or (ii) substituted with one or two radicals independently selected from the group consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, C₃-C₈-cycloalkyl and a C₁-C₆-alkanoyl group and an amino-

25 C₁-C₆-alkyl group wherein the aminoalkyl nitrogen is (i) unsubstituted or (ii) substituted with one or two radicals independently selected from the group consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, C₃-C₈-cycloalkyl and a C₁-C₆-alkanoyl group;

R⁷ is selected from the group consisting of a benzyl, phenyl, C₁-C₆-alkyl, C₃-C₆-alkynyl, C₃-C₆-alkenyl and a C₁-C₆-hydroxyalkyl group;

R⁸ and R⁹ and R¹⁰ and R¹¹ are independently
5 selected from the group consisting of a hydrido, hydroxy, C₁-C₆-alkyl, aryl, ar-C₁-C₆-alkyl, heteroaryl, heteroar-C₁-C₆-alkyl, C₂-C₆-alkynyl, C₂-C₆-alkenyl, thiol-C₁-C₆-alkyl, C₁-C₆-alkylthio-C₁-C₆-alkyl cycloalkyl, cycloalkyl-C₁-C₆-alkyl,
10 heterocycloalkyl-C₁-C₆-alkyl, C₁-C₆-alkoxy-C₁-C₆-alkyl, aralkoxy-C₁-C₆-alkyl, C₁-C₆-alkoxy-C₁-C₆-alkoxy-C₁-C₆-alkyl, hydroxy-C₁-C₆-alkyl, hydroxycarbonyl-C₁-C₆-alkyl, hydroxycarbonylar-C₁-C₆-alkyl, aminocarbonyl-C₁-C₆-alkyl, aryloxy-C₁-C₆-alkyl, heteroaryloxy-C₁-C₆-alkyl, arylthio-C₁-C₆-alkyl, heteroarylthio-C₁-C₆-alkyl, the sulfoxide or sulfone of any said thio substituents, perfluoro-C₁-C₆-alkyl, trifluoromethyl-C₁-C₆-alkyl, halo-C₁-C₆-alkyl, alkoxycarbonylamino-C₁-C₆-alkyl and an amino-
15 C₁-C₆-alkyl group wherein the aminoalkyl nitrogen is (i) unsubstituted or (ii) substituted with one or two radicals independently selected from the group consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, cycloalkyl and C₁-C₆-alkanoyl, or wherein R⁸ and R⁹ or R¹⁰ and
20 R¹¹ and the carbon to which they are bonded form a carbonyl group, or wherein R⁸ and R⁹ or R¹⁰ and R¹¹, or R⁸ and R¹⁰ together with the atoms to which they are bonded form a 5- to 8-membered carbocyclic ring,

or a 5- to 8-membered heterocyclic ring containing one or two heteroatoms that are nitrogen, oxygen, or sulfur, with the proviso that only one of R⁸ and R⁹ or R¹⁰ and R¹¹ is hydroxy;

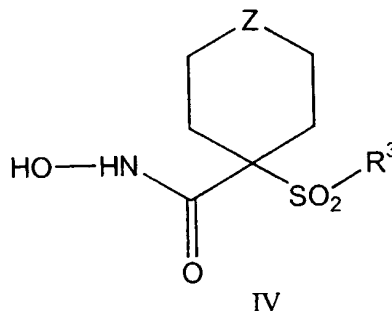
- 5 R¹² and R^{12'} are independently selected from the group consisting of a hydrido, C₁-C₆-alkyl, aryl, ar-C₁-C₆-alkyl, heteroaryl, heteroaralkyl, C₂-C₆-alkynyl, C₂-C₆-alkenyl, thiol-C₁-C₆-alkyl, cycloalkyl, cycloalkyl-C₁-C₆-alkyl, heterocycloalkyl-
10 C₁-C₆-alkyl, C₁-C₆-alkoxy-C₁-C₆-alkyl, aryloxy-C₁-C₆-alkyl, amino-C₁-C₆-alkyl, C₁-C₆-alkoxy-C₁-C₆-alkoxy-C₁-C₆-alkyl, hydroxy-C₁-C₆-alkyl, hydroxycarbonyl-C₁-C₆-alkyl, hydroxycarbonylar-C₁-C₆-alkyl, aminocarbonyl-C₁-C₆-alkyl, aryloxy-C₁-C₆-alkyl,
15 heteroaryloxy-C₁-C₆-alkyl, C₁-C₆-alkylthio-C₁-C₆-alkyl, arylthio-C₁-C₆-alkyl, heteroarylthio-C₁-C₆-alkyl, the sulfoxide or sulfone of any said thio substituents, perfluoro-C₁-C₆-alkyl, trifluoromethyl-C₁-C₆-alkyl, halo-C₁-C₆-alkyl, alkoxycarbonylamino-C₁-C₆-alkyl and an amino-C₁-C₆-alkyl group wherein
20 the aminoalkyl nitrogen is (i) unsubstituted or (ii) substituted with one or two radicals independently selected from the group consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, cycloalkyl and C₁-C₆-alkanoyl; and
25 R¹³ is selected from the group consisting of a hydrido, benzyl, phenyl, C₁-C₆-alkyl, C₂-C₆-alkynyl, C₂-C₆-alkenyl and a C₁-C₆-hydroxyalkyl group. Again, the use of a compound of formula III as a

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pharmaceutically acceptable salt is also contemplated.

Preferences related to a compound of formula III that also apply to a compound of formula II include the following, which are independently preferred: (a) the sum of $m + n + p = 1$ or 2 , and more preferably 2 ; (b) Z is O , S or NR^6 ; (c) R^6 is selected from the group consisting of C_3 - C_6 -cycloalkyl, C_1 - C_6 -alkyl, C_3 - C_6 -alkenyl, C_3 - C_6 -alkynyl, C_1 - C_6 -alkoxy- C_1 - C_6 -alkyl, amino- C_1 - C_6 -alkyl, aminosulfonyl, heteroaryl- C_1 - C_6 -alkyl, aryloxy carbonyl, and C_1 - C_6 -alkoxycarbonyl; and (d) $m = n = \text{zero}$, $p = 1$, and Y is NR^6 . Another preference for a compound of both of formulas II and III is that R^{14} be hydrido, or that W of the $C(W)R^{15}$ pro-drug form be O and R^{15} be a C_1 - C_6 -alkyl, aryl, C_1 - C_6 -alkoxy, heteroaryl- C_1 - C_6 -alkyl, C_3 - C_8 -cycloalkyl- C_1 - C_6 -alkyl, or aryloxy group.

A still more preferred compound for use in a contemplated process corresponds in structure to formula IV, below:



Here, R^3 is as defined above as to formulas I, III and more preferably as defined as to formula II

(wherein the R^3 radical is the substituent G-A-R-E-Y). Most preferably, R^3 is as defined in formula III.

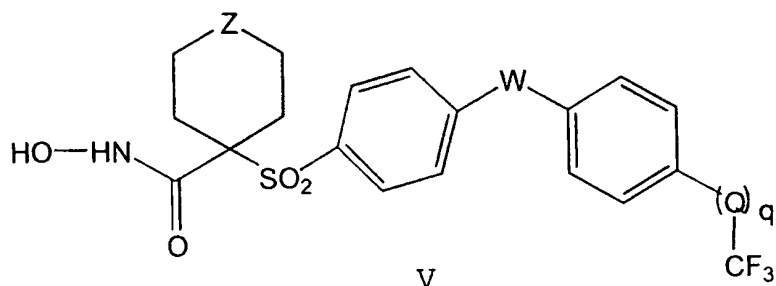
Z is selected group the group consisting of O,
5 S, NR^6 , SO, SO_2 , and NSO_2R^7 ,

wherein R^6 is selected from the group consisting of hydrido, C_1 - C_5 -alkyl, C_1 - C_5 -alkanoyl, benzyl, benzoyl, C_3 - C_5 -alkynyl, C_3 - C_5 -alkenyl, C_1 - C_3 -alkoxy-
10 C_1 - C_4 -alkyl, C_3 - C_6 -cycloalkyl, heteroaryl- C_1 - C_6 -alkyl, C_1 - C_5 -hydroxyalkyl, C_1 - C_5 -carboxyalkyl, C_1 - C_5 -alkoxy C_1 - C_5 -alkylcarbonyl, and NR^8R^9 - C_1 - C_5 -alkylcarbonyl or NR^8R^9 - C_1 - C_5 -alkyl wherein R^8 and R^9 are independently hydrido, C_1 - C_5 -alkyl, C_1 - C_5 -alkoxycarbonyl or aryl- C_1 - C_5 -alkoxycarbonyl, or NR^8R^9
15 together form a heterocyclic ring containing 5- to 8-atoms in the ring; and

R^7 is selected from the group consisting of an arylalkyl, aryl, heteroaryl, heterocyclo, C_1 - C_6 -alkyl, C_3 - C_6 -alkynyl, C_3 - C_6 -alkenyl, C_1 - C_6 -
20 carboxyalkyl and a C_1 - C_6 -hydroxyalkyl group. Most preferably, Z is O or NR^6 . Here too, the use of a compound of formula IV as a pharmaceutically acceptable salt is contemplated.

A still more preferred group of contemplated
25 compounds for use in a contemplated process correspond in structure to formula V, below;

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wherein

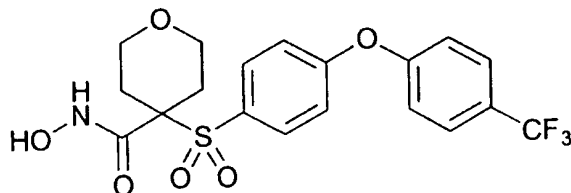
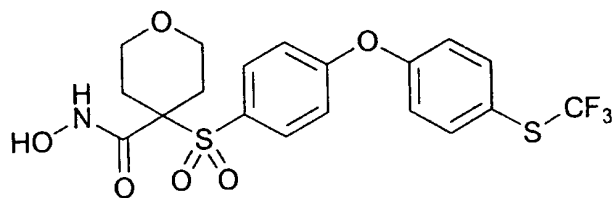
Z is as previously defined for formula IV;

5 W and Q are independently oxygen (O), NR^6 or sulfur (S), and R^6 is as defined in formula IV; and

q is zero or one such that when q is zero, Q is absent and the trifluoromethyl group is bonded directly to the depicted phenyl ring. Here again, the use of a compound of formula IV as a pharmaceutically acceptable salt is contemplated.

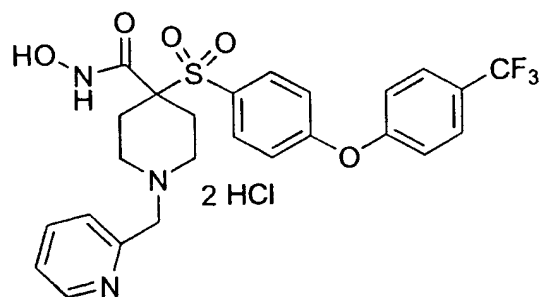
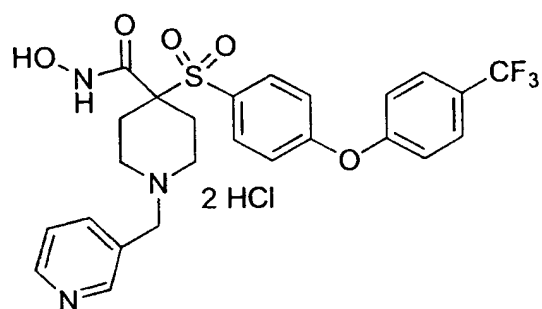
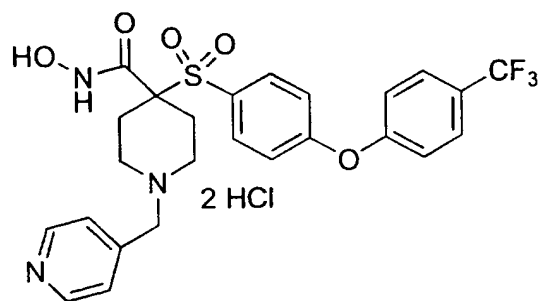
10 Particularly preferred compounds within the group defined by formula V have the structural formulas shown below:

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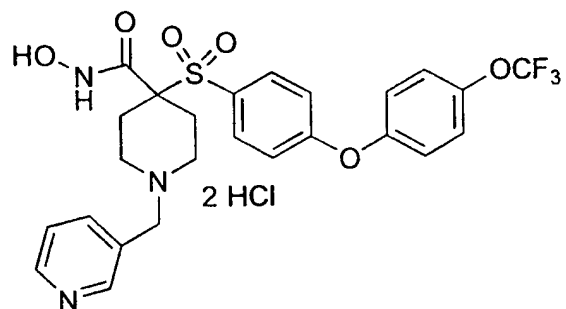


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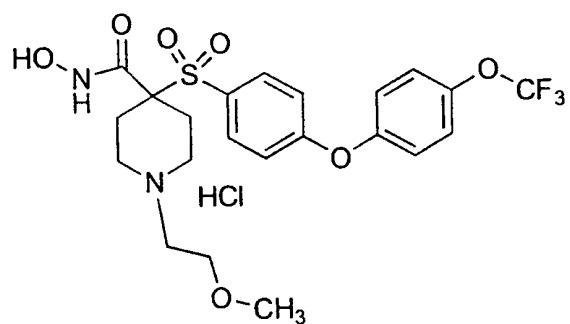
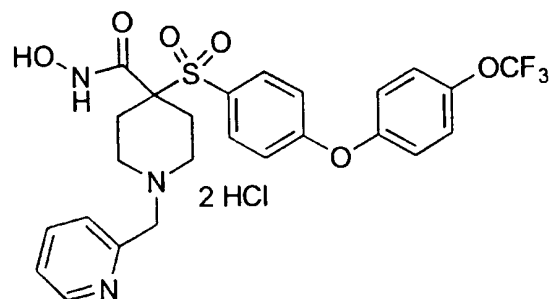
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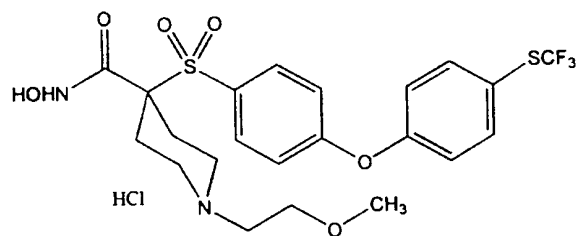
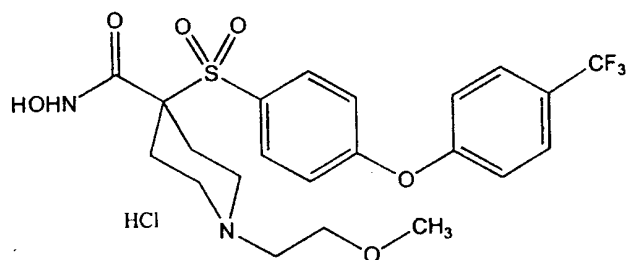
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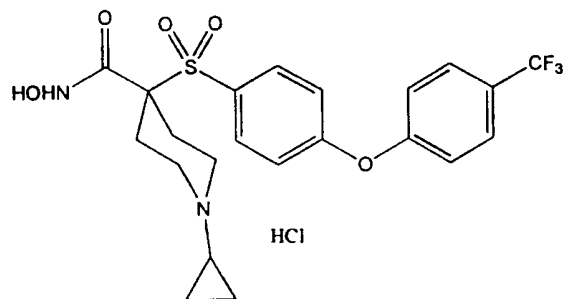
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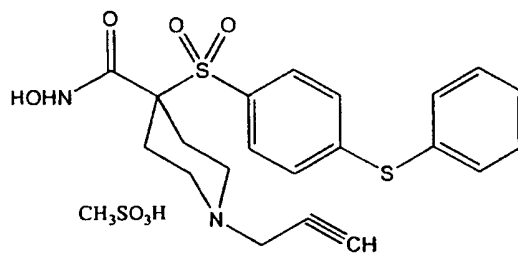
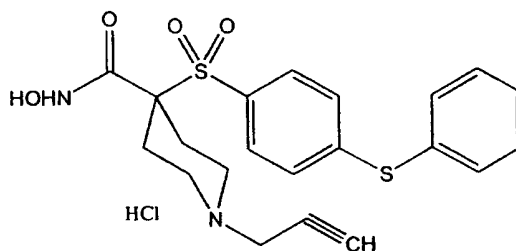
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Also particularly preferred are the following
5 compounds:



10

Several particularly preferred compounds whose structures correspond to formulas I through V are illustrated in the Tables and examples provided hereinafter.

15

As was noted before, the compounds of formulas II, III, IV and V, and their pharmaceutically acceptable salts are themselves contemplated compounds of the invention.

In preferred practice, an SO₂-linked R³ radical is an aryl or heteroaryl group that is a 5- or 6-membered single-ring that is itself substituted with one other single-ringed aryl or heteroaryl group or, with an alkyl or alkoxy group having a chain length of 3 to about 16 carbon atoms (and more preferably a length of up to about 14 carbon atoms), a phenoxy group, a thiophenoxy [C₆H₅-S-] group, a phenylazo [C₆H₅-N₂-] group, a N-piperidyl [C₅H₁₀N-] group, a N-piperazyl [NC₄H₉N-] group or a benzamido [-NHC(O)C₆H₅] group. The SO₂-linked single-ringed aryl or heteroaryl R³ group here is substituted at its own 4-position when a 6-membered ring and at its own 3- or 4-position when a 5-membered ring.

The SO₂-linked aryl or heteroaryl group of a R³ radical is preferably itself substituted at the 4-position when a 6-membered ring or the 3- or 4-position when a 5-membered ring. A particularly preferred substituent is a single-ringed aryl or heteroaryl, phenoxy, thiophenoxy, phenylazo, N-piperidyl, N-piperazyl or benzamido group that is unsubstituted or can itself be substituted.

The 4- and 3-positions of rings discussed here are numbered from the sites of substituent bonding as compared to formalized ring numbering positions used in heteroaryl nomenclature, as is discussed further hereinbelow. Here, single atoms such as halogen moieties (fluoro, chloro, bromo, or iodo) or substituents that contain one to a chain length of about five atoms other than hydrogen such as phenyl, C₁-C₄ alkyl, trifluoromethyl,

trifluoromethoxy, trifluorothiomethyl or carboxyethyl groups are preferred, although longer substituents can be accommodated up to a total length of an icosyl group.

- 5 Exemplary particularly preferred substituted SO₂-linked R³ radicals include 4-(phenyl)phenyl [biphenyl], 4-(4'-methoxyphenyl)-phenyl, 4-(phenoxy)phenyl, 4-(thiophenyl)phenyl [4-(phenylthio)phenyl], 4-(azophenyl)phenyl, 4-[(4'-trifluoromethylthio)phenoxy]phenyl, 4-[(4'-trifluoromethylthio)thiophenyl]phenyl, 4-[(4'-trifluoromethyl)phenoxy]phenyl, 4-[(4'-trifluoromethyl)thiophenyl]phenyl, 4-[(4'-trifluoromethoxy)phenoxy]phenyl, 4-[(4'-trifluoromethoxy)thiophenyl]phenyl, 4-[(4'-phenyl)N-piperidyl]phenyl, 4-[(4'-acetyl)N-piperazyl]phenyl and 4-(benzamido)phenyl.
- 10
- 15

- Inasmuch as a contemplated SO₂-linked aryl or heteroaryl radical of an R³ group is itself preferably substituted with a 6-membered ring, two nomenclature systems are used together herein for ease in understanding substituent positions. The first system uses position numbers for the ring directly bonded to the SO₂-group, whereas the second system uses ortho, meta or para for the position of one or more substituents of a 6-membered ring bonded to a SO₂-linked aryl or heteroaryl radical. Although ortho, meta and para positional nomenclature is normally not used with aliphatic ring systems, it is believed more readily understood for describing the present compounds when used in conjunction with the numerical system for the first ring bonded to the
- 20
- 25
- 30

SO₂-group. When a R³ radical is other than a 6-membered ring, substituent positions are numbered from the position of linkage to the aromatic or heteroaromatic ring. Formal chemical nomenclature is
5 used in naming particular compounds.

Thus, the 1-position of an above-discussed SO₂-linked aryl or heteroaryl group is the position at which the SO₂-group is bonded to the ring. The 4- and 3-positions of rings discussed here are numbered
10 from the sites of substituent bonding from the SO₂-linkage as compared to formalized ring numbering positions used in heteroaryl nomenclature.

When examined along its longest chain of atoms, an R³ radical including its own substituent
15 has a total length that is greater than a saturated chain of five carbon atoms (a pentyl group), and preferably has a length greater than that of a saturated chain of six carbon atoms (a hexyl group); i.e., a length of about a heptyl chain or longer. An
20 R³ radical also has a length that is less than that of a saturated chain of about 20 carbon atoms [an icosyl group (icosyl was formerly spelled eicosyl)] and more preferably about 18 carbon atoms (a stearyl group). Most preferably, the length of R³ is about
25 that of an 8 to about 12 carbon atom chain, even though many more atoms may be present in ring structures or substituents. This length requirement is discussed further below.

Looked at more generally, and aside from
30 specific moieties from which it is constructed, an R³ radical (group or moiety) has a length that is

greater than that of a pentyl group. Such an R^3 radical also has a length that is less than that of an icosyl (didecyl) group. That is to say that R^3 is a radical having a minimal length longer than a
5 saturated five carbon chain, and preferably greater than a hexyl group, but is shorter than the length of a saturated twenty carbon atom chain, and preferably shorter than an eighteen carbon chain. Most preferably, R^3 has a length greater than that of an
10 octyl group and less than that of a lauryl group.

More specifically, an R^3 group has a minimal length of a hexyl group only when that substituent is comprised of two rings that can be fused or simply covalently linked together by
15 exocyclic bonding. When R^3 does not contain two linked or fused rings, e.g., where a R^3 radical includes an alkyl or second, third or fourth ring substituent, R^3 has a length that is greater than that of a hexyl group. Exemplary of such two ring R^3
20 groups are a 2-naphthyl group or a 2-quinolinyl group (each with a six carbon chain length) and 8-purinyl (with a five carbon atom chain length). Without wishing to be bound by theory, it is believed that the presence of multiple rings in R^3 enhances
25 selectivity of the enzyme activity inhibitor profile.

The radical chain lengths are measured along the longest linear atom chain in the radical, following the skeletal atoms around a ring where necessary. Each atom in the chain, e.g. carbon,
30 oxygen, sulfur or nitrogen, is presumed to be carbon for ease in calculation.

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Such lengths can be readily determined by using published bond angles, bond lengths and atomic radii, as needed, to draw and measure a desired, usually staggered, chain, or by building models using commercially available kits whose bond angles, lengths and atomic radii are in accord with accepted, published values. Radical (substituent) lengths can also be determined somewhat less exactly by assuming that all atoms have bond lengths saturated carbon, that unsaturated bonds have the same lengths as saturated bonds and that bond angles for unsaturated bonds are the same as those for saturated bonds, although the above-mentioned modes of measurement are preferred. For example, a phenyl or pyridyl group has a length of a four carbon chain, as does a propoxy group, whereas a biphenyl group has a length of about an eight carbon chain using such a measurement mode.

In addition, a R^3 group when rotated about an axis drawn through the SO_2 -bonded 1-position and the 4-position of a 6-membered ring or the SO_2 -bonded position and substituent-bonded 3- or 4-position of a 5-membered ring defines a three-dimensional volume whose widest dimension has the width of about one furanyl ring to about two phenyl rings in a direction transverse to that axis to rotation.

Thus, a 2-naphthyl substituent or an 8-puriny l substituent is an appropriately sized R^3 group when examined using the above rotational width criterion as well as the before-discussed criterion. On the other hand, a 1-naphthyl group or a 7- or 9-

purinyl group is too wide upon rotation and is excluded from being an R^3 group.

As a consequence of these length and width requirements, R^3 radicals such as 4-(phenyl)phenyl
5 [biphenyl], 4-(4'-methoxyphenyl)-phenyl,
4-(phenoxy)phenyl, 4-(thiophenyl)phenyl [4-(phenylthio)phenyl], 4-(azophenyl)phenyl, 4-[(4'-trifluoromethylthio)phenoxy]phenyl, 4-[(4'-trifluoromethylthio)thiophenyl]phenyl, 4-[(4'-
10 trifluoromethyl)phenoxy]phenyl, 4-[(4'-trifluoromethyl)thiophenyl]phenyl, 4-[(4'-trifluoromethoxy)phenoxy]phenyl, 4-[(4'-trifluoromethoxy)thiophenyl]phenyl, 4-[(4'-phenyl)N-piperidyl]phenyl, 4-[(4'-acetyl)N-piperazyl]phenyl
15 and 4-(benzamido)phenyl are particularly preferred R^3 radicals. Those substituents can themselves also be substituted in the second ring from the SO_2 group at the meta- or para-position or both with a single atom or a substituent containing a longest chain length
20 that is preferably of up to five atoms, excluding hydrogen.

Without wishing to be bound by theory, the length of a R^3 radical substituent bonded to the SO_2 group is believed to play a role in the overall
25 activity of a contemplated inhibitor compound against MMP enzymes generally. The length of the R^3 radical group also appears to play a role in the selective activity of an inhibitor compound against particular MMP enzymes.

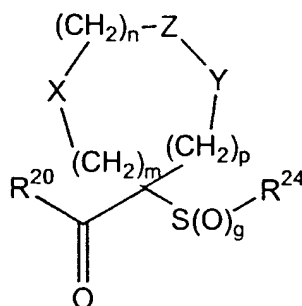
30 In particularly preferred practice, R^3 is a PhR^{23} group, wherein Ph is phenyl. The phenyl ring

(Ph) of a PhR^{23} group is substituted at its para-position (4-position) by an R^{23} group that can be another single-ringed aryl or heteroaryl group, a piperidyl group, a piperazinyl group, a phenoxy group, a thiophenoxy [$\text{C}_6\text{H}_5\text{-S-}$] group, a phenylazo [$\text{C}_6\text{H}_5\text{-N}_2\text{-}$] group or a benzamido [$\text{-NHC(O)C}_6\text{H}_5$] group.

In one embodiment of a particularly preferred aromatic sulfone hydroxamate inhibitor compound, an R^{23} substituent is phenoxy and is itself substituted at its own para-position with a moiety that is selected from the group consisting of a halogen, a $\text{C}_1\text{-C}_4$ alkoxy group, a $\text{C}_1\text{-C}_4$ alkyl group, a dimethylamino group, a carboxyl $\text{C}_1\text{-C}_3$ alkylene group, a $\text{C}_1\text{-C}_4$ alkoxy carbonyl $\text{C}_1\text{-C}_3$ alkylene group, a trifluoromethylthio group, a trifluoromethoxy group, a trifluoromethyl group and a carboxamido $\text{C}_1\text{-C}_3$ alkylene group, or is substituted at the meta- and para-positions by a methylenedioxy group. It is to be understood that any R^{23} substituent can be substituted with a moiety from the above list. Such substitution at the para-position is preferred.

The present invention also contemplates an intermediate compound that is useful in preparing a compound of formulas I-V. Such an intermediate compound corresponds in structure to formula VI, below:

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VI

wherein g is zero, 1 or 2;

- 5 R^{20} is (a) $-O-R^{21}$, where R^{21} is selected from the group consisting of a hydrido, C_1 - C_6 -alkyl, aryl, ar- C_1 - C_6 -alkyl group and a pharmaceutically acceptable cation, or (b) $-NH-O-R^{22}$ wherein R^{22} is a selectively removable protecting group such as a 2-
 10 tetrahydropyranyl, C_1 - C_6 -acyl, aroyl, benzyl, p-methoxybenzyl (MOZ) carbonyl- C_1 - C_6 -alkoxy, trisubstituted silyl group or o-nitrophenyl group, peptide synthesis resin and the like, wherein trisubstituted silyl group is substituted with C_1 - C_6 -
 15 alkyl, aryl, or ar- C_1 - C_6 -alkyl;

m is zero, 1 or 2;

n is zero, 1 or 2;

p is zero, 1 or 2;

the sum of $m + n + p = 1, 2, 3$ or 4;

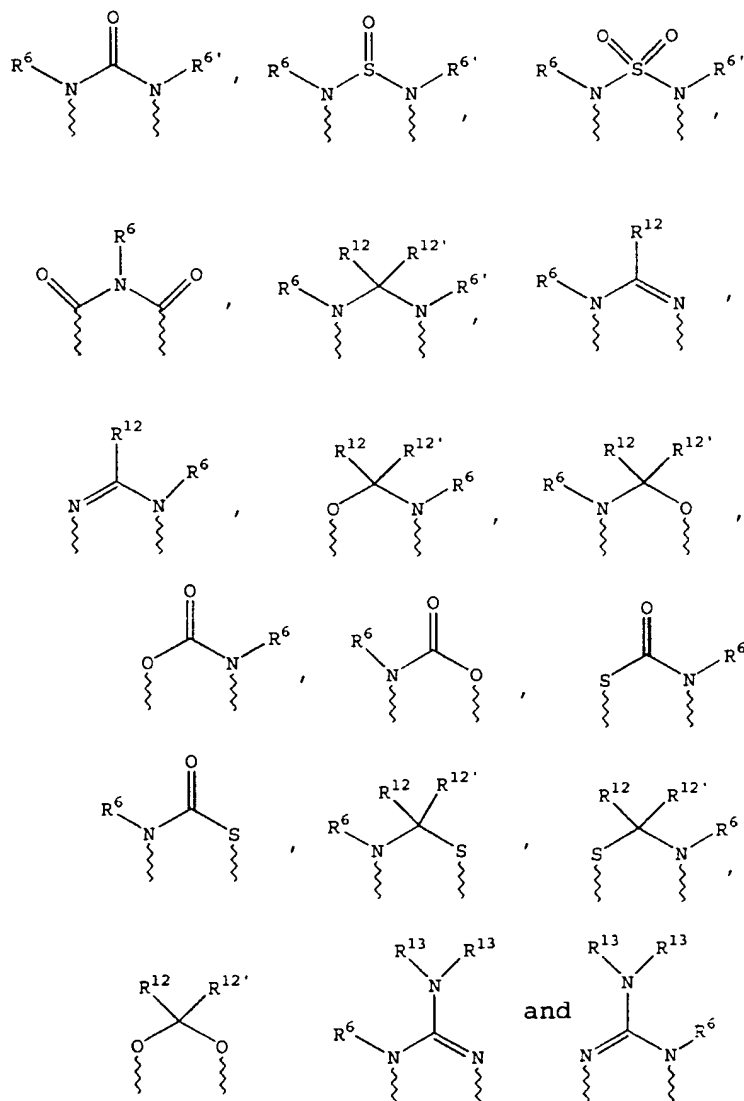
- 20 (a) one of X , Y and Z is selected from the group consisting of $C(O)$, NR^6 , O , S , $S(O)$, $S(O)_2$ and $NS(O)_2R^7$, and the remaining two of X , Y and Z are CR^8R^9 , and $CR^{10}R^{11}$, or

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(b) X and Z or Z and Y together constitute a moiety that is selected from the group consisting of $\text{NR}^6\text{C}(\text{O})$, $\text{NR}^6\text{S}(\text{O})$, $\text{NR}^6\text{S}(\text{O})_2$, NR^6S , NR^6O , SS , NR^6NR^6 and $\text{OC}(\text{O})$, with the remaining one of X, Y and Z being

5 CR^8R^9 , or

(c) n is zero and X, Y and Z together constitute a moiety selected from the group consisting of



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wherein wavy lines are bonds to the atoms of the depicted ring;

- R^6 and $R^{6'}$ are independently selected from the group consisting of hydrido, C_1 - C_6 -alkanoyl, C_6 -aryl-
5 C_1 - C_6 -alkyl, aroyl, bis(C_1 - C_6 -alkoxy- C_1 - C_6 -alkyl)- C_1 - C_6 -alkyl, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -perfluoroalkyl, C_1 - C_6 -trifluoromethylalkyl, C_1 - C_6 -perfluoroalkoxy- C_1 - C_6 -alkyl, C_1 - C_6 -alkoxy- C_1 - C_6 -alkyl, C_3 - C_6 -cycloalkyl, C_3 - C_8 -heterocycloalkyl, C_3 -
10 C_8 -heterocycloalkylcarbonyl, C_6 -aryl, C_5 - C_6 -heterocyclo, C_5 - C_6 -heteroaryl, C_3 - C_8 -cycloalkyl- C_1 - C_6 -alkyl, C_6 -aryloxy- C_1 - C_6 -alkyl, heteroaryloxy- C_1 - C_6 -alkyl, heteroaryl- C_1 - C_6 -alkoxy- C_1 - C_6 -alkyl, heteroarylthio- C_1 - C_6 -alkyl, C_6 -arylsulfonyl, C_1 - C_6 -alkylsulfonyl, C_5 - C_6 -heteroarylsulfonyl, carboxy- C_1 -
15 C_6 -alkyl, C_1 - C_4 -alkoxycarbonyl- C_1 - C_6 -alkyl, aminocarbonyl, C_1 - C_6 -alkyliminocarbonyl, C_6 -aryliminocarbonyl, C_5 - C_6 -heterocycloiminocarbonyl, C_6 -arylthio- C_1 - C_6 -alkyl, C_1 - C_6 -alkylthio- C_1 - C_6 -alkyl, C_6 -arylthio- C_3 - C_6 -alkenyl, C_1 - C_4 -alkylthio- C_3 - C_6 -alkenyl, C_5 - C_6 -heteroaryl- C_1 - C_6 -alkyl, halo- C_1 - C_6 -alkanoyl, hydroxy- C_1 - C_6 -alkanoyl, thiol- C_1 - C_6 -alkanoyl, C_3 - C_6 -alkenyl, C_3 - C_6 -alkynyl, C_1 - C_4 -alkoxy- C_1 - C_4 -alkyl, C_1 - C_5 -alkoxycarbonyl, aryloxycarbonyl,
20 NR^8R^9 - C_1 - C_5 -alkylcarbonyl, hydroxy- C_1 - C_5 -alkyl, an aminocarbonyl wherein the aminocarbonyl nitrogen is (i) unsubstituted or (ii) substituted with one or two radicals independently selected from the group

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consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, C₃-C₈-cycloalkyl and a C₁-C₆-alkanoyl group, hydroxyaminocarbonyl, an aminosulfonyl group wherein the aminosulfonyl nitrogen is (i) unsubstituted or
5 (ii) substituted with one or two radicals independently selected from the group consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, C₃-C₈-cycloalkyl and a C₁-C₆-alkanoyl group, an amino-C₁-C₆-alkylsulfonyl group wherein the amino-C₁-C₆-alkylsulfonyl nitrogen
10 is (i) unsubstituted or (ii) substituted with one or two radicals independently selected from the group consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, C₃-C₈-cycloalkyl and a C₁-C₆-alkanoyl group and an amino-C₁-C₆-alkyl group wherein the aminoalkyl nitrogen is
15 (i) unsubstituted or (ii) substituted with one or two radicals independently selected from the group consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, C₃-C₈-cycloalkyl and a C₁-C₆-alkanoyl group;

R⁷ is selected from the group consisting of
20 a benzyl, phenyl, C₁-C₆-alkyl, C₃-C₆-alkynyl, C₃-C₆-alkenyl and a C₁-C₆-hydroxyalkyl group;

R⁸ and R⁹ and R¹⁰ and R¹¹ are independently selected from the group consisting of a hydrido, hydroxy, C₁-C₆-alkyl, aryl, ar-C₁-C₆-alkyl,
25 heteroaryl, heteroar-C₁-C₆-alkyl, C₂-C₆-alkynyl, C₂-C₆-alkenyl, thiol-C₁-C₆-alkyl, C₁-C₆-alkylthio-C₁-C₆-alkyl cycloalkyl, cycloalkyl-C₁-C₆-alkyl, heterocycloalkyl-C₁-C₆-alkyl, C₁-C₆-alkoxy-C₁-C₆-alkyl, aralkoxy-C₁-C₆-alkyl, C₁-C₆-alkoxy-C₁-C₆-

alkoxy-C₁-C₆-alkyl, hydroxy-C₁-C₆-alkyl,
hydroxycarbonyl-C₁-C₆-alkyl, hydroxycarbonylar-C₁-C₆-
alkyl, aminocarbonyl-C₁-C₆-alkyl, aryloxy-C₁-C₆-
alkyl, heteroaryloxy-C₁-C₆-alkyl, arylthio-C₁-C₆-
5 alkyl, heteroarylthio-C₁-C₆-alkyl, the sulfoxide or
sulfone of any said thio substituents, perfluoro-C₁-
C₆-alkyl, trifluoromethyl-C₁-C₆-alkyl, halo-C₁-C₆-
alkyl, alkoxycarbonylamino-C₁-C₆-alkyl and an amino-
C₁-C₆-alkyl group wherein the aminoalkyl nitrogen is
10 (i) unsubstituted or (ii) substituted with one or two
radicals independently selected from the group
consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, cycloalkyl
and C₁-C₆-alkanoyl, or wherein R⁸ and R⁹ or R¹⁰ and
R¹¹ and the carbon to which they are bonded form a
15 carbonyl group, or wherein R⁸ and R⁹ or R¹⁰ and R¹¹,
or R⁸ and R¹⁰ together with the atoms to which they
are bonded form a 5- to 8-membered carbocyclic ring,
or a 5- to 8-membered heterocyclic ring containing
one or two heteroatoms that are nitrogen, oxygen, or
20 sulfur, with the proviso that only one of R⁸ and R⁹
or R¹⁰ and R¹¹ is hydroxy;

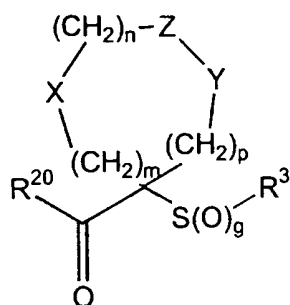
R¹² and R^{12'} are independently selected from the
group consisting of a hydrido, C₁-C₆-alkyl, aryl, ar-
C₁-C₆-alkyl, heteroaryl, heteroaralkyl, C₂-C₆-
25 alkynyl, C₂-C₆-alkenyl, thiol-C₁-C₆-alkyl,
cycloalkyl, cycloalkyl-C₁-C₆-alkyl, heterocycloalkyl-
C₁-C₆-alkyl, C₁-C₆-alkoxy-C₁-C₆-alkyl, aryloxy-C₁-C₆-
alkyl, amino-C₁-C₆-alkyl, C₁-C₆-alkoxy-C₁-C₆-alkoxy-

C₁-C₆-alkyl, hydroxy-C₁-C₆-alkyl, hydroxycarbonyl-C₁-C₆-alkyl, hydroxycarbonylar-C₁-C₆-alkyl, aminocarbonyl-C₁-C₆-alkyl, aryloxy-C₁-C₆-alkyl, heteroaryloxy-C₁-C₆-alkyl, C₁-C₆-alkylthio-C₁-C₆-alkyl, arylthio-C₁-C₆-alkyl, heteroarylthio-C₁-C₆-alkyl, the sulfoxide or sulfone of any said thio substituents, perfluoro-C₁-C₆-alkyl, trifluoromethyl-C₁-C₆-alkyl, halo-C₁-C₆-alkyl, alkoxy-carbonylamino-C₁-C₆-alkyl and an amino-C₁-C₆-alkyl group wherein the aminoalkyl nitrogen is (i) unsubstituted or (ii) substituted with one or two radicals independently selected from the group consisting of C₁-C₆-alkyl, ar-C₁-C₆-alkyl, cycloalkyl and C₁-C₆-alkanoyl;

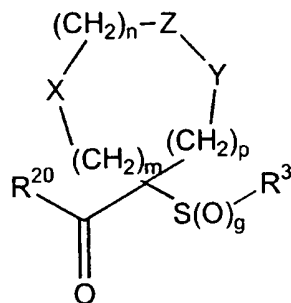
R¹³ is selected from the group consisting of a hydrido, benzyl, phenyl, C₁-C₆-alkyl, C₂-C₆-alkynyl, C₂-C₆-alkenyl and a C₁-C₆-hydroxyalkyl group; and

R²⁴ is R³ as defined in formulas I, III, IV or is the substituent G-A-R-E-Y of formula II

(formula VIA). Alternatively, R²⁴ is R^{3'}, an aryl or heteroaryl group that is substituted with a coupling substituent reactive for coupling with another moiety (formula VIB), such as a nucleophilically displaceable leaving group, D.



VIA



VIB

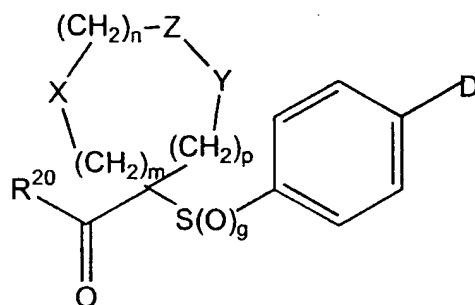
Exemplary nucleophilically displaceable leaving groups, D, include a halo (fluoro, chloro, bromo, or idodo) nitro, azido, phenylsulfoxido, aryloxy, C₁-C₆-alkoxy, a C₁-C₆-alkylsulfonate or arylsulfonate group and a trisubstituted ammonium group in which the three substituents are independently aryl, ar-C₁-C₆-alkyl or C₁-C₆-alkyl. Additional coupling substituents include, without limitation, a hydroxyl group and an amino group that can be coupled with carbonyl-containing moieties to form esters, urethanes, carbonates, amides and ureas. Similarly, a carboxyl coupling substituent can be used to form an ester, thioester or amide. Thus, a coupling substituent is useful in converting a coupling substituent-containing aryl or heteroaryl group into a substituent such as a G-A-R-E-Y substituent discussed hereinabove by the formation of a covalent bond.

A compound of formula VI can be coupled with another moiety at the R^{3'} coupling substituent to form a compound whose newly formed R³ group is that of formulas I, III, IV or -G-A-R-E-Y. Exemplary of such couplings are the nucleophilic displacement to form ethers and thioethers, as well as the formation

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of ester, amide, urea, carbonate, urethane and the like linkages.

A particularly preferred precursor intermediate to an intermediate compound of formula VI is an intermediate compound of formula VII, below



VII

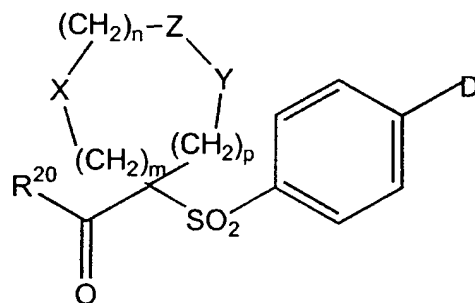
wherein m, n, p, g, X, Z, Y, D and R²⁰ are as defined above for formula VI.

R²⁰ is preferably -NH-O-R²², wherein R²² is a selectively removable protecting group such as a 2-tetrahydropyranyl, C₁-C₆-acyl, aroyl, benzyl, p-methoxybenzyl (MOZ) carbonyl-C₁-C₆-alkoxy, o-nitrophenyl group, a peptide synthesis resin such as a so-called Merrifield's Peptide Resin commercially available from Sigma Chemical Co., and the like, with 2-tetrahydropyranyl being particularly preferred. An -NH-O-R²² group (R²⁰) in formulas VI and VII is therefore seen to be a reaction product of a hydroxyl amine whose oxygen is bonded to a selectively removable protecting group and a carboxyl group.

In regard to a compound of each of formulas VI and VII, the subscript letter "g" is used to show the oxidation state of the sulfur atom. Where g is zero,

the sulfur is unoxidized, and the compound depicted is typically the sulfide reaction product of a sulfur-containing synthon as is illustrated in the examples hereinafter. Where g is 1, the sulfur is
 5 oxidized to a sulfoxide, whereas when g is 2, the sulfur is oxidized to a sulfone as is also illustrated hereinafter. A compound of formulas VI or VII wherein g is zero or 1 are themselves typically intermediates in the formation of a similar
 10 compound wherein g is 2 and the intermediate is a preferred sulfone.

A preferred intermediate therefore corresponds in structure to formula VIIA, below



VIIA

In the written descriptions of molecules and groups, molecular descriptors can be combined to produce words or phrases that describe structural
 20 groups or are combined to describe structural groups. Such descriptors are used in this document. Common illustrative examples include such terms as aralkyl (or arylalkyl), heteroaralkyl, heterocycloalkyl, cycloalkylalkyl, aralkoxyalkoxycarbonyl and the like.
 25 A specific example of a compound encompassed with the latter descriptor aralkoxyalkoxycarbonyl is C₆H₅-CH₂-

CH₂-O-CH₂-O-(C=O)- wherein C₆H₅- is phenyl. It is also to be noted that a structural group can have more than one descriptive word or phrase in the art, for example, heteroaryloxyalkylcarbonyl can also be
5 termed heteroaryloxyalkanoyl. Such combinations are used herein in the description of the processes, compounds and compositions of this invention and further examples are described below. The following list is not intended to be exhaustive or drawn out
10 but provide illustrative examples of words or phrases (terms) that are used herein.

As utilized herein, the term "alkyl", alone or in combination, means a straight-chain or branched-chain alkyl radical containing 1 to about 12
15 carbon atoms, preferably 1 to about 10 carbon atoms, and more preferably 1 to about 6 carbon atoms. Examples of such radicals include methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, tert-butyl, pentyl, iso-amyl, hexyl, octyl and the
20 like.

The term "alkenyl", alone or in combination, means a straight-chain or branched-chain hydrocarbon radical having one or more double bonds and containing 2 to about 12 carbon atoms preferably
25 2 to about 10 carbon atoms, and more preferably, 2 to about 6 carbon atoms. Examples of suitable alkenyl radicals include ethenyl (vinyl), 2-propenyl, 3-propenyl, 1,4-pentadienyl, 1,4-butadienyl, 1-butenyl, 2-butenyl, 3-butenyl, decenyl and the like.

30 The term "alkynyl", alone or in combination, means a straight-chain hydrocarbon radical having one or more triple bonds and containing 2 to about 12 carbon atoms, preferably 2

to about 10 carbon atoms, and more preferably, 2 to about 6 carbon atoms. Examples of alkynyl radicals include ethynyl, 2-propynyl, 3-propynyl, decynyl, 1-butynyl, 2-butynyl, 3-butynyl, and the like.

5 The term "carbonyl" or "oxo", alone or in combination, means a $-C(=O)-$ group wherein the remaining two bonds (valences) can be independently substituted. The term carbonyl is also intended to encompass a hydrated carbonyl group $-C(OH)_2-$.

10 The term "thiol" or "sulfhydryl", alone or in combination, means a $-SH$ group. The term "thio" or "thia", alone or in combination, means a thiaether group; i.e., an ether group wherein the ether oxygen is replaced by a sulfur atom.

15 The term "amino", alone or in combination, means an amine or $-NH_2$ group whereas the term mono-substituted amino, alone or in combination, means a substituted amine $-N(H)(\text{substituent})$ group wherein one hydrogen atom is replaced with a substituent, and
20 disubstituted amine means a $-N(\text{substituent})_2$ wherein two hydrogen atoms of the amino group are replaced with independently selected substituent groups.

 Amines, amino groups and amides are compounds that can be designated as primary (I°),
25 secondary (II°) or tertiary (III°) or unsubstituted, mono-substituted or N,N-disubstituted depending on the degree of substitution of the amino nitrogen. Quaternary amine (ammonium) (IV°) means a nitrogen with four substituents $[-N^+(\text{substituent})_4]$ that is
30 positively charged and accompanied by a counter ion, whereas N-oxide means one substituent is oxygen and

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the group is represented as $[-N^+(\text{substituent})_3-O^-]$;
i.e., the charges are internally compensated.

The term "cyano", alone or in combination,
means a -C-triple bond-N ($-C\equiv N$) group. The term
5 "azido", alone or in combination, means a -N-triple
bond-N ($-N\equiv N$) group. The term "hydroxyl", alone or
in combination, means a -OH group. The term "nitro",
alone or in combination, means a $-NO_2$ group. The
term "azo", alone or in combination, means a -N=N-
10 group wherein the bonds at the terminal positions can
be independently substituted.

The term "hydrazino", alone or in
combination, means a -NH-NH- group wherein the
depicted remaining two bonds (valences) can be
15 independently substituted. The hydrogen atoms of the
hydrazino group can be replaced, independently, with
substituents and the nitrogen atoms can form acid
addition salts or be quaternized.

The term "sulfonyl", alone or in
20 combination, means a $-SO_2-$ group wherein the depicted
remaining two bonds (valences) can be independently
substituted. The term "sulfoxido", alone or in
combination, means a $-SO-$ group wherein the remaining
two bonds (valences) can be independently
25 substituted.

The term "sulfone", alone or in
combination, means a $-SO_2-$ group wherein the depicted
remaining two bonds (valences) can be independently
substituted. The term "sulfenamide", alone or in
30 combination, means a $-SON=$ group wherein the
remaining three depicted bonds (valences) can be
independently substituted. The term "sulfide", alone

or in combination, means a -S- group wherein the remaining two bonds (valences) can be independently substituted.

The term "alkoxy", alone or in combination,
5 means an alkyl ether radical wherein the term alkyl is as defined above. Examples of suitable alkyl ether radicals include methoxy, ethoxy, n-propoxy, isopropoxy, n-butoxy, iso-butoxy, sec-butoxy, tert-butoxy and the like.

10 The term "cycloalkyl", alone or in combination, means a cyclic alkyl radical that contains 3 to about 8 carbon atoms. The term "cycloalkylalkyl" means an alkyl radical as defined above that is substituted by a cycloalkyl radical
15 containing 3 to about 8, preferably 3 to about 6, carbon atoms. Examples of such cycloalkyl radicals include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl and the like.

A heterocyclic (heterocyclo) or heterocyclo
20 portion of a heterocyclocarbonyl, heterocyclooxy-carbonyl, heterocycloalkoxycarbonyl, or heterocycloalkyl group or the like is a saturated or partially unsaturated monocyclic, bicyclic or tricyclic heterocycle that contains one or more
25 hetero atoms selected from nitrogen, oxygen and sulphur. Such a moiety can be optionally substituted on one or more ring carbon atoms by halogen, alkyl, alkoxy, oxo, and the like, and/or on a secondary nitrogen atom (i.e., -NH-) of the ring by alkyl,
30 aralkoxycarbonyl, alkanoyl, aryl or arylalkyl or on a tertiary nitrogen atom (i.e., =N-) by oxido and that is attached via a carbon atom. The tertiary nitrogen

atom with three substituents can also be attached to form a N-oxide [=N(O)-] group.

The term "aryl", alone or in combination, means a 5- or 6-membered carbocyclic aromatic ring-containing moiety or a fused ring system containing two or three rings that have all carbon atoms in the ring; i.e., a carbocyclic aryl radical. Exemplary carbocyclic aryl radicals include phenyl, indenyl and naphthyl radicals.

The term "heteroaryl", alone or in combination means a 5- or 6-membered aromatic ring-containing moiety or a fused ring system (radical) containing two or three rings that have carbon atoms and also one or more heteroatoms in the ring(s) such as sulfur, oxygen and nitrogen. Examples of such heterocyclic or heteroaryl groups are pyrrolidinyl, piperidyl, piperazinyl, morpholinyl, thiamorpholinyl, pyrrolyl, imidazolyl (e.g., imidazol-4-yl, 1-benzylloxycarbonylimidazol-4-yl, and the like), pyrazolyl, pyridyl, pyrazinyl, pyrimidinyl, furyl, tetrahydrofuryl, thienyl, triazolyl, oxazolyl, oxadiazoyl, thiazolyl, thiadiazoyl, indolyl (e.g., 2-indolyl, and the like), quinolinyl, (e.g., 2-quinolinyl, 3-quinolinyl, 1-oxido-2-quinolinyl, and the like), isoquinolinyl (e.g., 1-isoquinolinyl, 3-isoquinolinyl, and the like), tetrahydroquinolinyl (e.g., 1,2,3,4-tetrahydro-2-quinolyl, and the like), 1,2,3,4-tetrahydroisoquinolinyl (e.g., 1,2,3,4-tetrahydro-1-oxo-isoquinolinyl, and the like), quinoxalinyl, β -carbolinyl, 2-benzofurancarbonyl, benzothiophenyl, 1-, 2-, 4- or 5-benzimidazolyl, and the like radicals.

When an aryl or heteroaryl radical is a substituting moiety (group, substituent, or radical), it can itself substituted, the last-named substituent is independently selected from the group consisting

5 of a cyano, perfluoroalkyl, trifluoromethoxy, trifluoromethylthio, haloalkyl, trifluoromethylalkyl, aralkoxycarbonyl, aryloxy, carbonyl, hydroxy, halo, alkyl, alkoxy, nitro, thiol, hydroxycarbonyl, aryloxy, arylthio, aralkyl,

10 aryl, arylcarbonylamino, heteroaryloxy, heteroarylthio, heteroaralkyl, cycloalkyl, heterocyclooxy, heterocyclothio, heterocycloamino, cycloalkyloxy, cycloalkylthio, heteroaralkoxy, heteroaralkylthio, aralkoxy, aralkylthio,

15 aralkylamino, heterocyclo, heteroaryl, arylazo, hydroxycarbonylalkoxy, alkoxy, carbonylalkoxy, alkanoyl, arylcarbonyl, aralkanoyl, alkanoyloxy, aralkanoyloxy, hydroxyalkyl, hydroxyalkoxy, alkylthio, alkoxyalkylthio, alkoxy, carbonyl,

20 aryloxyalkoxyaryl, arylthioalkylthioaryl, aryloxyalkylthioaryl, arylthioalkoxyaryl, hydroxycarbonylalkoxy, hydroxycarbonylalkylthio, alkoxy, carbonylalkoxy, alkoxy, carbonylalkylthio, amino,

25 wherein the amino nitrogen is (i) unsubstituted, or (ii) substituted with one or two substituents that are independently selected from the group consisting of an alkyl, aryl, heteroaryl, aralkyl, cycloalkyl, aralkoxycarbonyl, alkoxy, carbonyl, arylcarbonyl, aralkanoyl, heteroarylcarbonyl, heteroaralkanoyl and an

30 alkanoyl group, or (iii) wherein the amino nitrogen and two substituents attached thereto form a 5- to 8-membered heterocyclo or

heteroaryl ring containing zero to two additional heteroatoms that are nitrogen, oxygen or sulfur and which ring itself is (a) unsubstituted or (b) substituted with one or two groups independently selected from the group consisting of an aryl, alkyl, heteroaryl, aralkyl, heteroaralkyl, hydroxy, alkoxy, alkanoyl, cycloalkyl, heterocycloalkyl, alkoxycarbonyl, hydroxyalkyl, trifluoromethyl, benzofused heterocycloalkyl, hydroxyalkoxyalkyl, aralkoxycarbonyl, hydroxycarbonyl, aryloxycarbonyl, benzofused heterocycloalkoxy, benzofused cycloalkylcarbonyl, heterocycloalkylcarbonyl, and a cycloalkylcarbonyl group, carbonylamino wherein the carbonylamino nitrogen is (i) unsubstituted, or (ii) is the reacted amine of an amino acid, or (iii) substituted with one or two radicals selected from the group consisting of an alkyl, hydroxyalkyl, hydroxyheteroaralkyl, cycloalkyl, aralkyl, trifluoromethylalkyl, heterocycloalkyl, benzofused heterocycloalkyl, benzofused heterocycloalkyl, benzofused cycloalkyl, and an N,N-dialkylsubstituted alkylamino-alkyl group, or (iv) the carboxamido nitrogen and two substituents bonded thereto together form a 5- to 8-membered heterocyclo, heteroaryl or benzofused heterocycloalkyl ring that is itself unsubstituted or substituted with one or two radicals independently selected from the group consisting of an alkyl, alkoxycarbonyl, nitro, heterocycloalkyl,

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- hydroxy, hydroxycarbonyl, aryl, aralkyl,
heteroaralkyl and an amino group,
wherein the amino nitrogen is
(i) unsubstituted, or (ii) substituted with
5 one or two substituents that are
independently selected from the group
consisting of alkyl, aryl, and heteroaryl,
or (iii) wherein the amino nitrogen and two
substituents attached thereto form a 5- to
10 8-membered heterocyclo or heteroaryl ring,
and an aminoalkyl group
wherein the aminoalkyl nitrogen is (i) unsubstituted,
or (ii) substituted with one or two substituents
independently selected from the group consisting of
15 an alkyl, aryl, aralkyl, cycloalkyl,
aralkoxycarbonyl, alkoxycarbonyl, and an alkanoyl
group, or (iii) wherein the aminoalkyl nitrogen and
two substituents attached thereto form a 5- to 8-
membered heterocyclo or heteroaryl ring.
- 20 The term "aralkyl", alone or in
combination, means an alkyl radical as defined above
in which one hydrogen atom is replaced by an aryl
radical as defined above, such as benzyl, 2-
phenylethyl and the like.
- 25 The term "aralkoxycarbonyl", alone or in
combination, means a radical of the formula aralkyl-
O-C(O)- in which the term "aralkyl" has the
significance given above. An example of an
aralkoxycarbonyl radical is benzyloxycarbonyl.
- 30 The term "aryloxy" means a radical of the
formula aryl-O- in which the term aryl has the

significance given above. The phenoxy radical is an exemplary aryloxy radical.

The terms "heteroaralkyl" and "heteroaryloxy" mean radicals structurally similar to aralkyl and aryloxy that are formed from heteroaryl radicals. Exemplary radicals include 4-picolinyl and 2-pyrimidinoxy, respectively.

The terms "alkanoyl" or "alkylcarbonyl", alone or in combination, means an acyl radical derived from an alkanecarboxylic acid, examples of which include formyl, acetyl, propionyl, butyryl, valeryl, 4-methylvaleryl, and the like.

The term "cycloalkylcarbonyl" means an acyl group derived from a monocyclic or bridged cycloalkanecarboxylic acid such as cyclopropanecarbonyl, cyclohexanecarbonyl, adamantanecarbonyl, and the like, or from a benz-fused monocyclic cycloalkanecarboxylic acid that is optionally substituted by, for example, alkanoylamino, such as 1,2,3,4-tetrahydro-2-naphthoyl, 2-acetamido-1,2,3,4-tetrahydro-2-naphthoyl.

The terms "aralkanoyl" or "aralkylcarbonyl" mean an acyl radical derived from an aryl-substituted alkanecarboxylic acid such as phenylacetyl, 3-phenylpropionyl (hydrocinnamoyl), 4-phenylbutyryl, (2-naphthyl)acetyl, 4-chlorohydrocinnamoyl, 4-aminohydrocinnamoyl, 4-methoxyhydrocinnamoyl and the like.

The terms "aroyl" or "arylcarbonyl" means an acyl radical derived from an aromatic carboxylic acid. Examples of such radicals include aromatic carboxylic acids, an optionally substituted benzoic

or naphthoic acid such as benzoyl, 4-chlorobenzoyl, 4-carboxybenzoyl, 4-(benzyloxycarbonyl)benzoyl, 1-naphthoyl, 2-naphthoyl, 6-carboxy-2 naphthoyl, 6-(benzyloxycarbonyl)-2-naphthoyl, 3-benzyloxy-
5 2-naphthoyl, 3-hydroxy-2-naphthoyl, 3-(benzyloxyformamido)-2-naphthoyl, and the like.

The term "cycloalkylalkoxycarbonyl" means an acyl group of the formula cycloalkylalkyl-O-CO- wherein cycloalkylalkyl has the significance given
10 above. The term "aryloxyalkanoyl" means an acyl radical of the formula aryl-O-alkanoyl wherein aryl and alkanoyl have the significance given above. The term "heterocyclooxycarbonyl" means an acyl group having the formula heterocyclo-O-CO- wherein
15 heterocyclo is as defined above.

The term "heterocycloalkanoyl" is an acyl radical of the formula heterocyclo-substituted alkane carboxylic acid wherein heterocyclo has the significance given above. The term
20 "heterocycloalkoxycarbonyl" means an acyl radical of the formula heterocyclo-substituted alkane-O-CO- wherein heterocyclo has the significance given above. The term "heteroaryloxy carbonyl" means an acyl radical represented by the formula heteroaryl-O-CO-
25 wherein heteroaryl has the significance given above.

The term "aminocarbonyl" (carboxamide) alone or in combination, means an amino-substituted carbonyl (carbamoyl) group derived from an amine reacted with a carboxylic acid wherein the amino
30 (amido nitrogen) group is unsubstituted (-NH₂) or a substituted primary or secondary amino group containing one or two substituents selected from the group consisting of hydrogen, alkyl, aryl, aralkyl,

cycloalkyl, cycloalkylalkyl radicals and the like, as recited. A hydroxamate is a N-hydroxycarboxamide.

The term "aminoalkanoyl" means an acyl group derived from an amino-substituted

5 alkanecarboxylic acid wherein the amino group can be a primary or secondary amino group containing substituents independently selected from hydrogen, alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl radicals and the like.

10 The term "halogen" means fluoride, chloride, bromide or iodide. The term "haloalkyl" means an alkyl radical having the significance as defined above wherein one or more hydrogens are replaced with a halogen. Examples of such haloalkyl
15 radicals include chloromethyl, 1-bromoethyl, fluoromethyl, difluoromethyl, trifluoromethyl, 1,1,1-trifluoroethyl and the like.

The term "perfluoroalkyl" means an alkyl group wherein each hydrogen has been replaced by a
20 fluorine atom. Examples of such perfluoroalkyl groups, in addition to trifluoromethyl above, are perfluorobutyl, perfluoroisopropyl, perfluorododecyl and perfluorodecyl.

The term "perfluoroalkoxy" alone or in
25 combination, means a perfluoroalkyl ether radical wherein the term perfluoroalkyl is as defined above. Examples of such perfluoroalkoxy groups, in addition to trifluoromethoxy ($\text{F}_3\text{C-O-}$), are perfluorobutoxy, perfluoroisopropoxy, perfluorododecoxy and
30 perfluorodecoxy.

The term "perfluoroalkylthio" alone or in combination, means a perfluoroalkyl thioether radical wherein the term perfluoroalkyl is as defined above.

Examples of such perfluoroalkylthio groups, in addition to trifluoromethylthio ($\text{F}_3\text{C-S-}$), are perfluorobutylthio, perfluoroisopropylthio, perfluorododecylthio and perfluorodecylthio.

5 The term "aromatic ring" in combinations such as substituted-aromatic ring sulfone or substituted-aromatic ring sulfoxide means aryl or heteroaryl as defined before.

 The term "pharmaceutically acceptable" is
10 used adjectivally herein to mean that the modified noun is appropriate for use in a pharmaceutical product. Pharmaceutically acceptable cations include metallic ions and organic ions. More preferred metallic ions include, but are not limited to
15 appropriate alkali metal (Group Ia) salts, alkaline earth metal (Group IIa) salts and other physiological acceptable metal ions. Exemplary ions include aluminum, calcium, lithium, magnesium, potassium, sodium and zinc in their usual valences. Preferred
20 organic ions include protonated tertiary amines and quaternary ammonium cations, including in part, trimethylamine, diethylamine, N,N' -dibenzylethylenediamine, chloroprocaine, choline, diethanolamine, ethylenediamine, meglumine (N-
25 methylglucamine) and procaine. Exemplary pharmaceutically acceptable acids include without limitation hydrochloric acid, hydrobromic acid, phosphoric acid, sulfuric acid, methanesulfonic acid, acetic acid, formic acid, tartaric acid, maleic acid,
30 malic acid, citric acid, isocitric acid, succinic acid, lactic acid, gluconic acid, glucuronic acid,

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pyruvic acid oxalacetic acid, fumaric acid, propionic acid, aspartic acid, glutamic acid, benzoic acid, and the like.

"M" utilized in the reaction schemes that follow represents a leaving group such as halogen, phosphate ester or sulfate ester.

10 Preparation of Useful Compounds

Schemes A through C and Schemes 1 through 19 hereinbelow illustrate chemical processes and transformations that can be useful for the preparation of compounds useful in this invention; i.e., compounds of formulas I, II, III, IV and V and similar cyclic inhibitors. In addition, the preparation of compounds of formula VI and formula VII is illustrated. Compounds of formula VI and formula VII can be used as intermediates in the preparation of the compounds of formulas I, II, III, IV and V or pro-drugs or MMP inhibitors.

In Schemes A through C, the symbol J independently represents R^{20} or other synthetically useful groups such as amides, acid chlorides, mixed anhydrides and the like. The n is 0, 1 or 2 and is preferred to be 1 or 2 in Scheme C. The n of these schemes corresponds to g in formulas VI and VII., and is zero, 1 or 2. The symbol m is 1 or 2. The symbol r is independently 1, 2 or 3. The symbol P represents a protecting group that can also be a member of the group R^6 . In Scheme A, for simplicity and clarity of illustration positional isomers are illustrated with a bond through the ring in standard

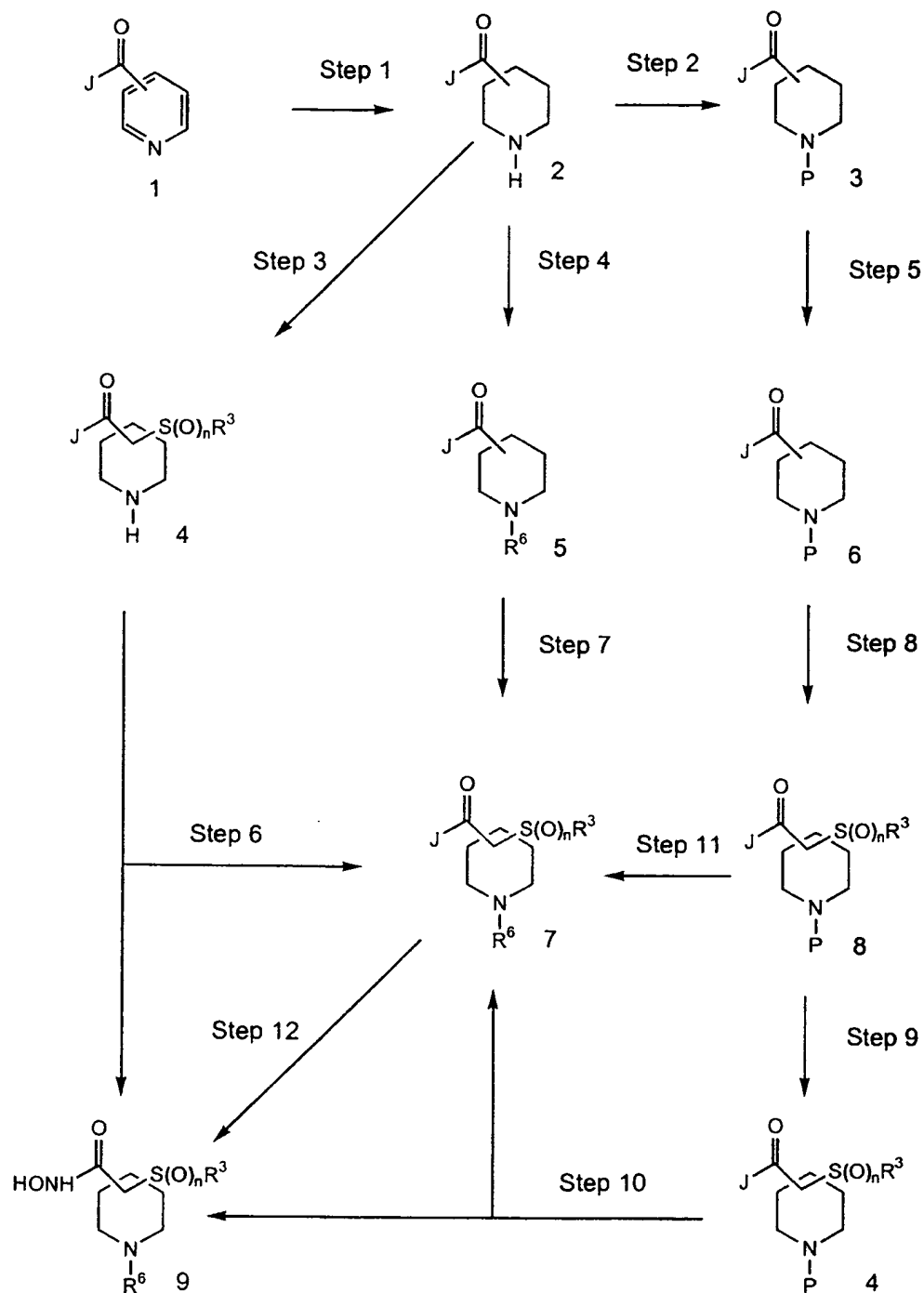
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fashion. Later Schemes typically only show one positional isomer but positional isomers are represented by these structures and reactions in a manner consistent with Formula I, II, III, IV, V, VI, 5 VII above. Similarly, the symbol B represents O, S, SO, SO₂ and NR⁶. The symbols C and C' independently are electrophilic groups or groups capable of participating in a condensation reaction. Here to it should be noted that the six-membered ring is shown 10 for illustrative purposes but the procedures and/or reagents are applicable to and represent combinations the permit the preparation of 5- to 8-membered rings.

The structures in Schemes 1 through 19 are also shown with compounds that represent the other 15 compounds of this invention. The aromatic ring in Scheme C is aryl and heteroaryl. The moieties of -A-R-E-Y are as defined before. Reactions illustrated involving a spiroheterocyclic nitrogen atom may not be applicable to those compounds with sulfur or 20 oxygen.

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Scheme A



Scheme A shows in step 1 the reduction of a heteraryl compound to a carboxyl derivative.

Generally, the first product is a hydrogen-containing amine heterocycle when the starting material is

5 aromatic or an R^6 -containing heterocycle when a partially unsaturated heterocycle is the starting material.

Compound 2 can be treated in several ways depending on the needs of the chemist. In Step 2, 10 the nitrogen can be protected by preparing, for example, a carbobenzoxy (Z) or tert-butoxycarbonyl derivative. Such acylations can be carried out by methods well known in the art, especially the art of amino acid and peptide synthesis. The process of 15 acylation with activated carboxyl group- or activated sulfonyl group-containing reagents to prepare contemplated compounds is carried out in the same manner. Examples of such acylating groups are carbonyl azides, halides, anhydrides, mixed 20 anhydrides, carbodiimide derivatives or other less traditional activated ester groups such as the hydroxybenzotriazole derivative. These acylations can be run in the presence of base including mild bases such as triethylamine or N-ethylmorpholine if 25 desired. The preparation of some activated ester reagents and their use to prepare other compounds useful in this invention is discussed below. It should be recalled that the groups constituting P and serving as a selectively removable protecting group 30 can also be included as part of the group R^6 .

Step 4 of Scheme A shows the alkylation or acylation of Compound 2 to produce compound 5. The

process of acylation and alkylation are as discussed herein. In Step 5, the group J can be changed if desired. An example of such a change is exchange of an ester for a THP-protected hydroxamate conversion
5 of a THP-protected hydroxamate into a hydroxamate or conversion of an acid into a protected hydroxamate or the like.

Steps 3, 7 and 8 show the preparation of sulfur-containing derivatives of the contemplated
10 compounds or intermediates to those compounds. The starting material for the above steps (e.g., compounds 2, 5 and 6) can be treated with a base to deprotonate the carbon alpha to the carbonyl function. This anion can be reacted with a sulfur
15 electrophile to produce a sulfone, sulfoxide or sulfide. Such electrophiles can be of the form of, for example, $R^{24}S-SR^{24}$, $R^{24}SO_2Cl$, $R^{24}SCl$, $R^{24}SOCl$, $R^{24}S(O)-SR^{24}$ and the like where R^{24} is as defined before or is an aryl or heteroaryl sulfur-containing
20 material containing a coupling substituent, $R^{3'}$, that can be used to prepare one of the R^{24} -containing groups. Preparation of the anion requires a base and a strong base may be required such as one of the metal amides, hydrides or alkyls discussed herein.
25 The solvents are nonprotic, and dipolar aprotic solvents are preferred along with an inert atmosphere. Subsequent schemes usually utilize R^3 for the R^{24} group for ease of illustration.

It should be noted that these processes
30 produce sulfides (thio ethers), sulfoxides or sulfones depending on starting material. In

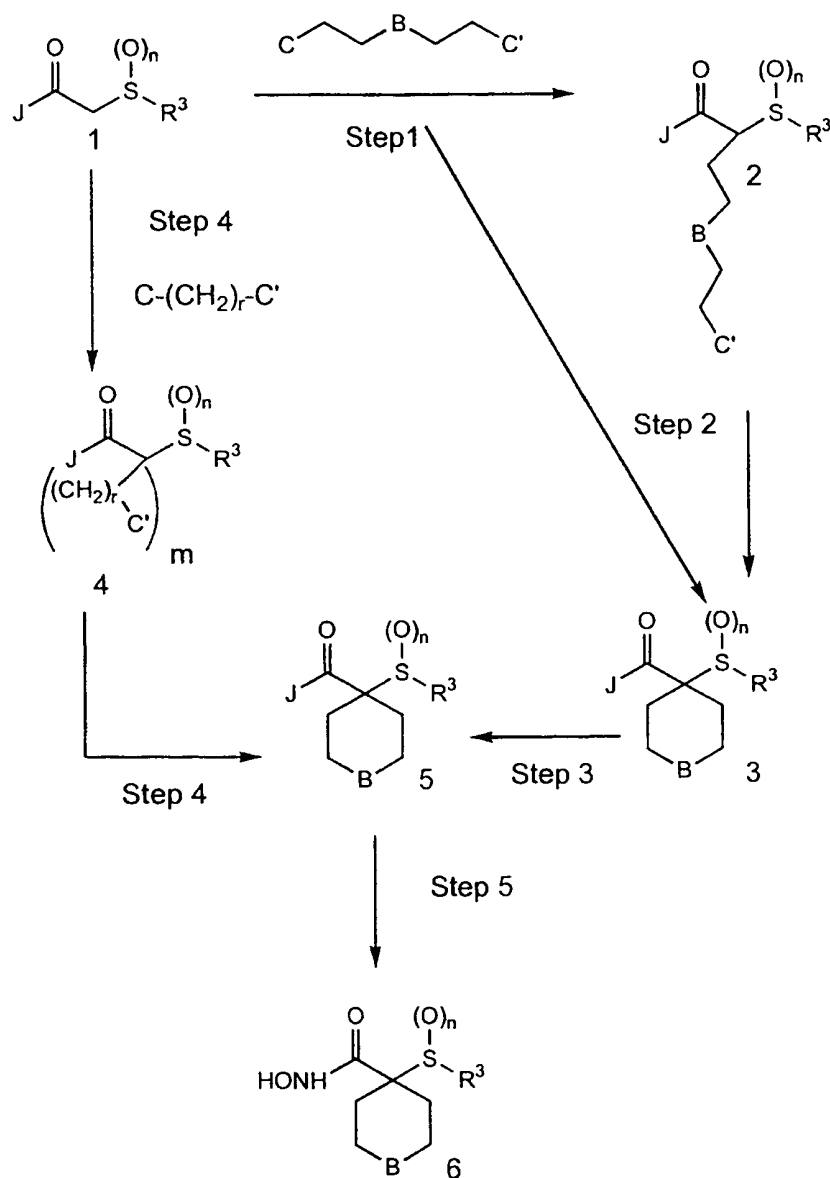
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addition, the sulfides can be oxidized to sulfoxides or sulfones, and the sulfoxides can be oxidized to their corresponding sulfone derivatives. The choice of position in the synthetic sequence to change the oxidation state of sulfur as well as the decision to change oxidation state is under the control of the chemist skilled in the art. Methods of oxidizing sulfur are discussed hereinbelow.

Scheme A, Steps 6, 9, 10 and 12

independently illustrate the interconversion of groups within J. Examples of such interconversions include exchange of an ester for hydroxamic acid or hydroxamic acid derivative, conversion of a carboxylic acid into an activated carbonyl derivative or into a hydroxamic acid or hydroxamic acid derivative (pro-drug or protected derivative), or removal of a protecting group from a hydroxamate derivative. The preparation of activated carbonyl compounds their reaction with nucleophiles such as hydroxamic acid, protected hydroxamates or hydroxamic acid pro-drugs is discussed below as is the conversion of protected hydroxamic acid derivatives into hydroxamic acids. The preparation of, for example, hydroxybenzotriazole/carbodiimide, derived products is discussed herein. The preparation or hydrolysis of esters, amides, amide derivatives, acid chlorides, acid anhydrides, mixed anhydrides and the like are synthetic methods very well known in the art, and are not discussed in detail herein. Step 6 illustrates the conversion of compound 4 into compound 9, without first being converted into compound 7.

Scheme B



5 Scheme B illustrates an alternate method of preparing contemplated compounds. The reagent shown above the arrow in Step 1 is a reagent with two

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active groups in addition to the heteroatoms (B) noted before. Here again, the particular reagent illustrated was selected to permit a clear illustration of the reaction, but it is also intended to represent reagents that permit the preparation of the heteroatom position, and 5-, 7- and 8-membered ring size compounds. These reagents are readily selected by those skilled in the art.

C and C' in this Step 1 reagent are independently an electrophile or a group convertible into an electrophile. Such groups include halides, sulfonic acid esters, epoxides, thioepoxides, hydroxyl groups, and the like. This reagent is reacted with a nucleophilic anion of a sulfur containing carbonyl compound such as compound 1. The anion is formed by deprotonation of compound 1 and examples of bases suitable for such a deprotonation are discussed below. Treatment with the above electrophilic reagent is carried out under alkylating conditions well known in the art and discussed herein. The product of this reaction can be either Compound 2 or Compound 3; i.e., the reaction can be carried out as a pot or two step process as required.

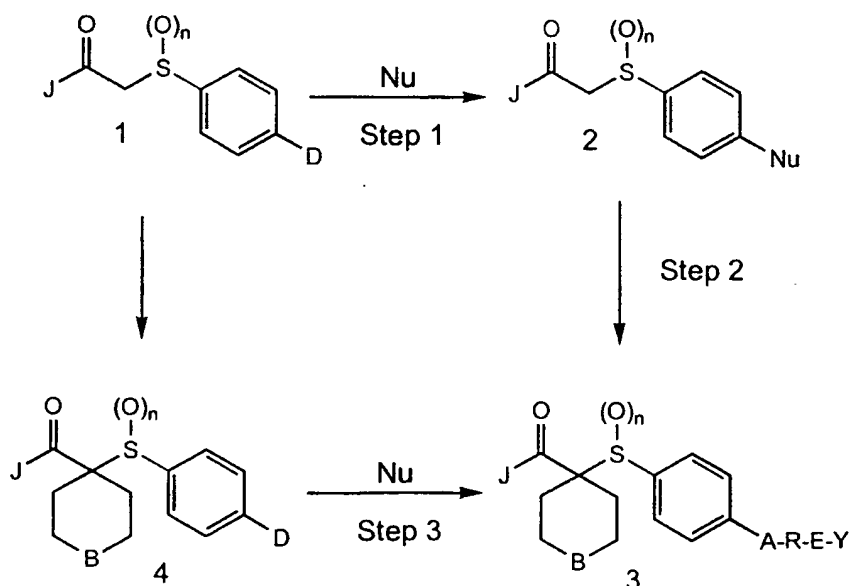
Step 3 illustrates the interconversion of J groups if desired as discussed above for Scheme A. Step 4 uses reagent where C, for example, represents a nucleophile as discussed above and C' represents an electrophile or a nucleophile such as hydroxyl, thiol or R⁶-amino. It is noted that C' can be, independently, a nucleophile or an electrophile when m is 2; i.e., the C' groups are not required to be the same when m is 2. When m is 2, treatment with a second mole of base provides the skilled chemist an

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alternative preparation of Compound 5. When C' is hydroxyl, thiol, or R⁶-amino and m is 2, the person skilled in the art can condense Compound 4 with, for example, an aldehyde or ketone, under reductive conditions or with subsequent reduction to form a contemplated compound. As above, the compound where m is 2 can be made in one step (one pot process) or two steps, thus permitting the chemist the choice of having the reagent(s) be the same (one pot) or different (two step).

Scheme B also illustrates the interconversions of the groups within J, the oxidation state of the sulfur and groups on nitrogen; i.e., R⁶ groups, to provide the contemplated compounds. These methods and processes are discussed above for the reactions of Scheme A.

Scheme C



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Scheme C illustrates the nucleophilic displacement of a group D as defined herein. This reaction is carried out in a similar manner to the displacement reactions discussed herein. The choice of oxidation state of the sulfur is made by the person skilled in the art, but sulfoxide or sulfone groups are preferred, and the sulfone is most preferred. The displacement can be carried out either before or after the methylene next to the carbonyl group is reacted to form a spiro heterocyclic group.

Steps 1, 2 and 3 also illustrate that although the nucleophilic displacement can be carried out with one nucleophile (Nu), the product of this reaction can be modified by methods well known in the art and as shown herein to provide the group -A-R-E-Y as defined hereinbefore.

A non-limiting illustration of such a process is provided when D is fluoride. The fluoride leaving group can be directly displaced with the anion of 4-trifluoromethylphenol, 4-trifluoromethoxyphenol, 4-trifluoromethylthiophenol and the like to provide a contemplated compound. This is a one pot process from Compound 4. Other compounds included in -A-R-E-Y can be prepared by displacing the fluoride leaving group with ammonia to provide an amine, which can then be acylated by methods discussed wherein with, for example, 4-trifluoromethylbenzoyl chloride, to form another contemplated product compound.

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The R⁶ function can be changed and/or further modified in compounds or at steps in the Schemes as desired or required by the person skilled in the art to prepare the contemplated compounds.

5 Interconversion of dual purpose functional groups such as short or long term protecting groups into other R⁶ groups has been mentioned. Many other routine and/or useful conversions, including the preparation of synthetic intermediates, are very well
10 known in the art. A few non-limiting examples of such conversions or reactions include: reductions; nucleophilic displacement/substitution reactions; exchange or preparation of carboxylic or sulfonic acids, amides, esters, acid halides, mixed anhydrides
15 and the like; electrophilic displacement/substitution reactions; oxidations; ring/chain conversions, ring opening reactions, condensation reactions including those involving sulfonyl or carbonyl groups and/or carbon-hydrogen bonds influenced by either or both of
20 those groups. The selection of preparative methods or conversion methods of the contemplated compounds and the order of the reaction(s) is made by the skilled person. It is expected that should a particular sequence or method prove to be undesirable
25 that an alternative will be selected and used. Included is the choice of preparing/adding the groups in a single step using a convergent inhibitor strategy or preparing the final R⁶ group following a stepwise strategy.

30 Thus, in general, the choices of starting material and reaction conditions can vary as is well known to those skilled in the art. Usually, no

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single set of conditions is limiting because variations can be applied as required. Conditions are also selected as desired to suit a specific purpose such as small scale preparations or large
5 scale preparations. In either case, the use of less safe or less environmentally sound materials or reagents is usually be minimized. Examples of such materials are diazomethane, diethyl ether, heavy metal salts, dimethyl sulfide, chloroform, benzene
10 and the like.

These reactions can be carried out under a dry inert atmosphere such a nitrogen or argon if desired. Selected reactions known to those skilled in the art, can be carried out under a dry atmosphere
15 such as dry air whereas other synthetic steps, for example, aqueous acid or base ester or amide hydrolysis, can be carried out under laboratory air. In addition, some processes of these syntheses can be carried out in a pressure apparatus at pressures
20 above, equal to or below atmospheric pressure. The use of such an apparatus aids in the control of gaseous reagents such as hydrogen, ammonia, trimethylamine, methylamine, oxygen and the like, and can also help prevent the leakage of air or humidity
25 into a reaction in progress. This discussion is not intended to be exhaustive as it is readily noted that additional or alternative methods, conditions, reactions or systems can be identified and used by a chemist of ordinary skill.

30 The illustrated reactions are usually carried out at a temperature of between -25°C to solvent reflux under an inert atmosphere such as nitrogen or argon. The solvent or solvent mixture

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can vary widely depending upon reagents and other conditions and can include polar or dipolar aprotic solvents as listed or mixtures of these solvents. Reactions can be carried out at lower temperatures
5 such as dry ice/acetone or liquid nitrogen temperature if desired to carry out such reactions as metalations or anion formations using strong bases.

In some cases, amines such as triethylamine, pyridine or other non-reactive bases
10 can serve as reagents and/or solvents and/or co-solvents. In some instances, in these reactions and other reactions in these Schemes, protecting groups can be used to maintain or retain groups in other parts of a molecule(s) at locations that is(are) not
15 desired reactive centers. Examples of such groups that the skilled person can maintain or retain include, amines, other hydroxyls, thiols, acids and the like. Such protecting groups can include acyl groups, arylalkyl groups, carbamoyl groups, ethers,
20 alkoxyalkyl ethers, cycloalkyloxy ethers, arylalkyl groups, silyl groups including trisubstituted silyl groups, ester groups and the like. Examples of such protecting groups include acetyl, trifluoroacetyl, tetrahydropyran (THP), benzyl, tert-butoxy carbonyl
25 (BOC or TBOC), benzyloxycarbonyl (Z or CBZ), tert-butyltrimethylsilyl (TBDMS) or methoxyethoxymethylene (MEM) groups. The preparation of such protected compounds as well as their removal is well known in the art. The protecting groups can also be used as
30 substituents in the contemplated compounds whose utility is as a drug rather than as a synthetic intermediate.

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Many reactions or processes involve bases that can act as reactants, reagents, deprotonating agents, acid scavengers, salt forming reagents, solvents, co-solvents and the like. Bases that can be used include, for example, metal hydroxides such as sodium, potassium, lithium, cesium or magnesium hydroxide, oxides such as those of sodium, potassium, lithium, calcium or magnesium, metal carbonates such as those of sodium, potassium, lithium, cesium, calcium or magnesium, metal bicarbonates such as sodium bicarbonate or potassium bicarbonate, primary (I°), secondary (II°) or tertiary (III°) organic amines such as alkyl amines, arylalkyl amines, alkylarylalkyl amines, heterocyclic amines or heteroaryl amines, ammonium hydroxides or quaternary ammonium hydroxides. As non-limiting examples, such amines can include triethylamine, trimethylamine, diisopropylamine, methyldiisopropylamine, diazabicyclononane, tribenzylamine, dimethylbenzylamine, morpholine, N-methylmorpholine, N,N'-dimethylpiperazine, N-ethylpiperidine, 1,1,5,5-tetramethylpiperidine, dimethylaminopyridine, pyridine, quinoline, tetramethylethylenediamine, and the like. Non-limiting examples of ammonium hydroxides, usually made from amines and water, can include ammonium hydroxide, triethylammonium hydroxide, trimethylammonium hydroxide, methyldiisopropylammonium hydroxide, tribenzylammonium hydroxide, dimethylbenzylammonium hydroxide, morpholinium hydroxide, N-methylmorpholinium hydroxide, N,N'-dimethylpiperazinium hydroxide, N-ethylpiperidinium hydroxide, and the like. As non-limiting examples,

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quaternary ammonium hydroxides can include tetraethylammonium hydroxide, tetramethylammonium hydroxide, dimethyldiisopropyl-ammonium hydroxide, benzylmethyldiisopropylammonium hydroxide, 5 methyldiazabicyclononylammonium hydroxide, methyltribenzylammonium hydroxide, N,N-dimethyl-morpholiniumhydroxide, N,N,N',N'-tetramethylpiperazinium hydroxide, and N-ethyl-N'-hexylpiperidinium hydroxide and the like.

10 Metal hydrides, amides or alcoholates such as calcium hydride, sodium hydride, potassium hydride, lithium hydride, aluminum hydride, diisobutylaluminum hydride (DIBAL) sodium methoxide, potassium tert-butoxide, calcium ethoxide, magnesium 15 ethoxide, sodium amide, potassium diisopropyl amide and the like can also be suitable reagents. Organometallic deprotonating agents such as alkyl or aryl lithium reagents such as methyl lithium, phenyl lithium, tert-butyl lithium, lithium acetylide or 20 butyl lithium, Grignard reagents such as methylmagnesium bromide or methymagnesium chloride, organocadmium reagents such as dimethylcadmium and the like can also serve as bases for causing salt formation or catalyzing the reaction. Quaternary 25 ammonium hydroxides or mixed salts are also useful for aiding phase transfer couplings or serving as phase transfer reagents. Pharmaceutically acceptable bases can be reacted with acids to form contemplated pharmaceutically acceptable salts. It should also be 30 noted that optically active bases can be used to make optically active salts which can be used for optical resolutions.

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Generally, reaction media can comprise a single solvent, mixed solvents of the same or different classes or serve as a reagent in a single or mixed solvent system. The solvents can be protic, non-protic or dipolar aprotic. Non-limiting examples of protic solvents include water, methanol (MeOH), denatured or pure 95% or absolute ethanol, isopropanol and the like. Typical non-protic solvents include acetone, tetrahydrofuran (THF), dioxane, diethyl ether, tert-butylmethyl ether (TBME), aromatics such as xylene, toluene, or benzene, ethyl acetate, methyl acetate, butyl acetate, trichloroethane, methylene chloride, ethylenedichloride (EDC), hexane, heptane, isooctane, cyclohexane and the like. Dipolar aprotic solvents include compounds such as dimethylformamide (DMF), dimethylacetamide (DMAC), acetonitrile, DMSO, hexamethylphosphorus triamide (HMPA), nitromethane, tetramethylurea, N-methylpyrrolidone and the like.

Non-limiting examples of reagents that can be used as solvents or as part of a mixed solvent system include organic or inorganic mono- or multi-protic acids or bases such as hydrochloric acid, phosphoric acid, sulfuric acid, acetic acid, formic acid, citric acid, succinic acid, triethylamine, morpholine, N-methylmorpholine, piperidine, pyrazine, piperazine, pyridine, potassium hydroxide, sodium hydroxide, alcohols or amines for making esters or amides or thiols for making contemplated products and the like.

The preparation of compounds contemplated herein can require the oxidation of nitrogen or sulfur to N-oxide derivatives or sulfoxides or sulfones. Reagents for this process can include, in

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a non-limiting example, peroxymonosulfate (OXONE®), hydrogen peroxide, meta-chloroperbenzoic acid, perbenzoic acid, peracetic acid, perlactic acid, tert-butyl peroxide, tert-butyl hypochlorite, sodium
5 hypochlorite, hypochlorous acid, sodium meta-periodate, periodic acid and the like with the weaker agents being most useful for the preparation of sulfones and sulfoxides. Protic, non-protic, dipolar aprotic solvents, either pure or mixed, can be
10 chosen, for example, methanol/water.

The oxidation can be carried out at temperature of about -78° to about 50° degrees Centigrade, and normally selected from a range -10°C to about 40°C. Sulfoxides are best prepared using
15 one equivalent of oxidizing agent. It can be desirable in the case of more active oxidizing agents, but not required, that the reactions be carried out under an inert gas atmosphere with or without degassed solvents. It should be noted that
20 the oxidation of sulfides to sulfones can be carried out in one step or two steps via the sulfoxide as desired by the chemist.

Reduction is a well known process in the art with a useful method being hydrogenation. In
25 such cases (catalytic reduction), there can be a metal catalyst such as Rh, Pd, Pt, Ni or the like with or without an additional support such as carbon, barium carbonate and the like. Solvents can be protic or non-protic pure solvents or mixed solvents
30 as required. The reductions can be carried out at atmospheric pressure to a pressure of multiple atmospheres with atmospheric pressure to about 40 pounds per square inch (psi) preferred or very high

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pressures in special hydrogenation equipment well known in the art.

Reductive alkylation of amines or active methylene compounds is also a useful method of preparing compounds. Such alkylations can be carried out under reductive hydrogenation conditions as presented above using, for example, aldehydes or ketones. Hydride transfer reagents such as sodium cyanoborohydride, aluminum hydride, lithium aluminumhydride, borane, sodium borohydride, di-isobutylaluminum hydride and the like are also useful as reagents for reductive alkylation. Acyl groups can be reduced in a similar manner to produce substituted amines.

Alternative methods of alkylating carbon or nitrogen are direct alkylation. Such an alkylation, as is well known in the art, can be carried by treatment of an activated carbon containing at least one hydrogen with base to form the corresponding anion, adding an electrophilic reagent and permitting the SN2 reaction to proceed. An amine to be alkylated is treated similarly except that deprotonation may not be required. Electrophiles include halogen derivatives, sulfonate esters, epoxides and the like.

Bases and solvents for alkylation reactions are those discussed above. Preferred are bases that are hindered such that competition with the electrophile is minimized. Additional preferred bases are metal hydrides, amide anions or organometallic bases such as n-butyl lithium. The solvents, solvent mixtures or solvent/reagent mixtures discussed are satisfactory but non-protic or

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dipolar aprotic solvents such as acetone, acetonitrile, DMF and the like are examples of preferred classes.

Acids are used in many reactions during various syntheses. For example, removal of the THP protecting group to produce the hydroxamic acid. The acid can be a mono-, di- or tri-protic organic or inorganic acid. Examples of acids include hydrochloric acid, phosphoric acid, sulfuric acid, acetic acid, formic acid, citric acid, succinic acid, hydrobromic acid, hydrofluoric acid, carbonic acid, phosphorus acid, p-toluene sulfonic acid, trifluoromethane sulfonic acid, trifluoroacetic acid, difluoroacetic acid, benzoic acid, methane sulfonic acid, benzene sulfonic acid, 2,6-dimethylbenzene sulfonic acid, trichloroacetic acid, nitrobenzoic acid, dinitrobenzoic acid, trinitrobenzoic acid, and the like. They can also be Lewis acids such as aluminum chloride, borontrifluoride, antimony pentafluoride and the like. Acids in a protic can also be used to hydrolyze esters, amides and the like as well as catalyze exchange reactions.

Conversion of a carboxylic acid protected as an ester or amide into a hydroxamic acid or hydroxamic acid derivative such as an O-arylalkylether or O-cycloalkoxyalkylether group is useful. In the case where hydroxylamine is used, treatment of an ester or amide with one or more equivalents of hydroxylamine hydrochloride at room temperature or above in a solvent or solvents, usually protic or partially protic, such as those listed above can provide a hydroxamic acid directly. This exchange process can be further catalyzed by the

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addition of additional acid. Alternatively, a base such as a salt of an alcohol used as a solvent, for example, sodium methoxide in methanol, can be used to form hydroxylamine from hydroxylamine hydrochloride in situ which can exchange with an ester or amide. As mentioned above, exchange can be carried out with a protected hydroxyl amine such as tetrahydropyranylhdroxyamine (THPONH₂), benzylhydroxylamine (BnONH₂), and the like in which case compounds such as shown in Schemes A, B and C that are tetrahydropyranyl (THP) or benzyl (Bn) hydroxamic acid derivatives are the products. Removal of the protecting groups when desired, for example, following further transformations in another part of the molecule or following storage, is accomplished by standard methods well known in the art such as acid hydrolysis of the THP group as discussed above or reductive removal of the benzyl group with hydrogen and a metal catalyst such as palladium, platinum, palladium on carbon or nickel.

In the case where R²⁰ is hydroxyl; i.e., where the intermediate is a carboxylic acid, standard coupling reactions can be used. For example, the acid can be converted into an acid chloride, mixed anhydride or activated ester such as hydroxybenzotriazole and treated with hydroxylamine or a protected hydroxylamine in the presence of a non-competitive base to the nitrogen acylated compound. This is the same product as discussed above. Couplings of this nature are well known in the art and especially the art related to peptide and amino acid chemistry.

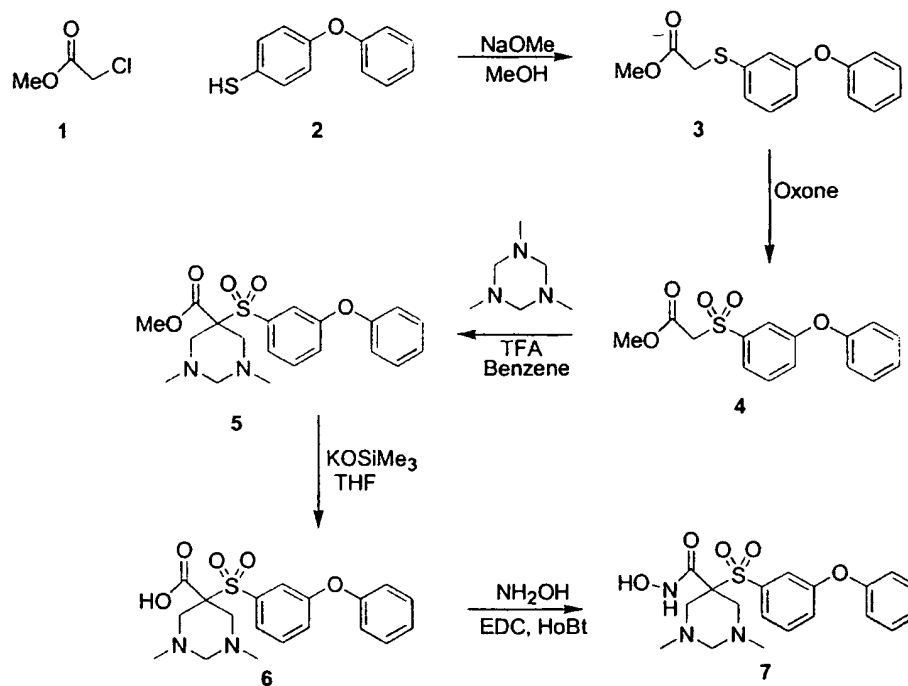
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Compounds contemplated herein can possess one or more asymmetric carbon atoms and are thus capable of existing in the form of optical isomers, enantiomers, diastereoisomers, as well as in the form of racemic or nonracemic mixtures. A compound can also exist in other isomeric forms such as ortho, meta and para isomers, cis and trans isomers, syn and anti isomers, E and Z isomers, tautomeric isomers, alpha and beta isomers, axial and equatorial isomers and isomers due to hindered rotation. An isomer can exist in equilibrium with another isomer in a mammal or a test system. Such a compound can also exist as an isomeric equilibrium system with a solvent or water, for example, as a hydrated ketone or aldehyde, as is well known in the art. All isomers are included as compounds of this invention.

The chemical reactions described above are generally disclosed in terms of their broadest application to the preparation of the compounds of this invention. Occasionally, the reactions may not be applicable as described to each compound included within the disclosed scope. The compounds for which this occurs will be readily recognized by those skilled in the art. In all such cases, either the reactions can be successfully performed by conventional modifications known to those skilled in the art, e.g., by appropriate protection of interfering groups, by changing to alternative conventional reagents, by routine modification of reaction conditions, and the like, or other reactions disclosed herein or otherwise conventional, are applicable to the preparation of the corresponding compounds that are contemplated.

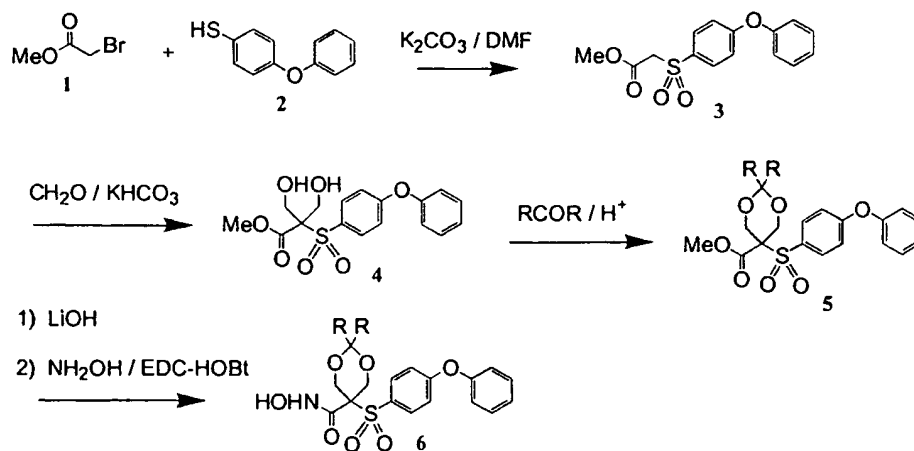
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Scheme 1



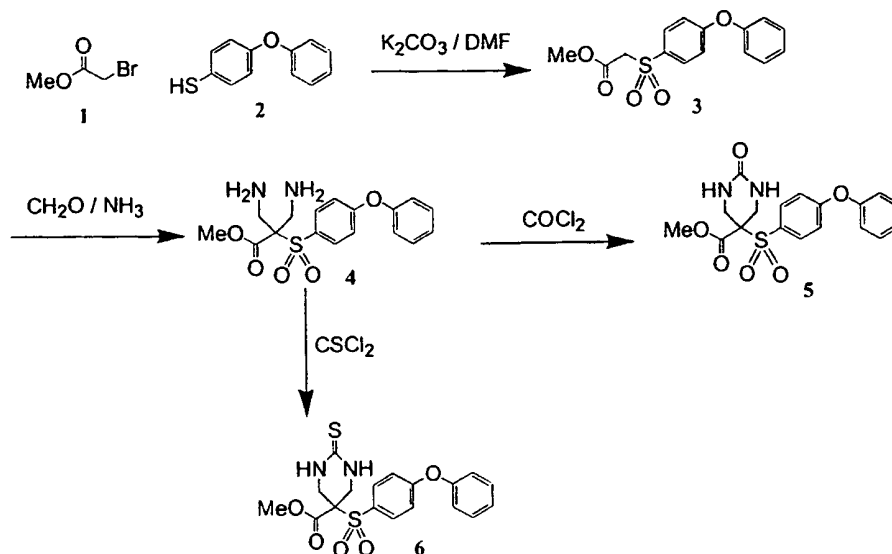
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Scheme 2

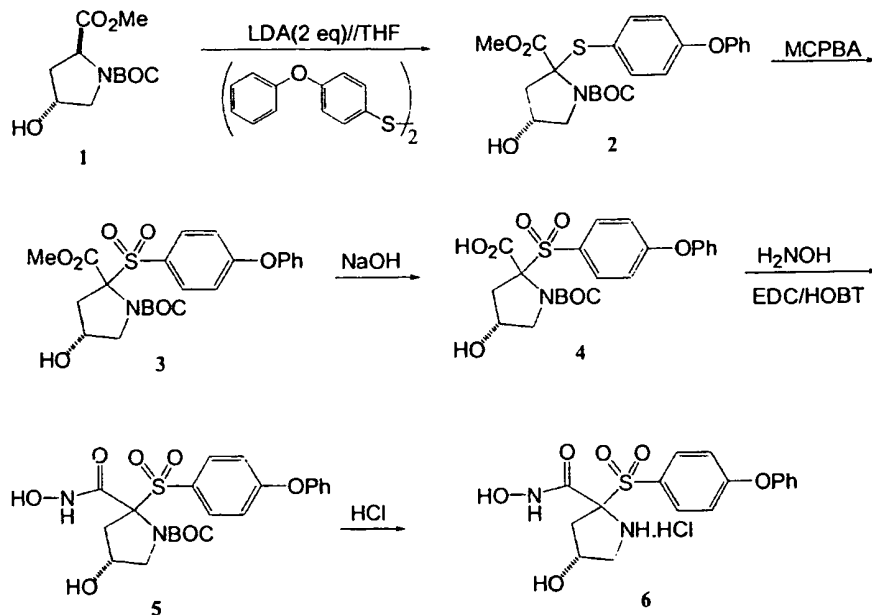


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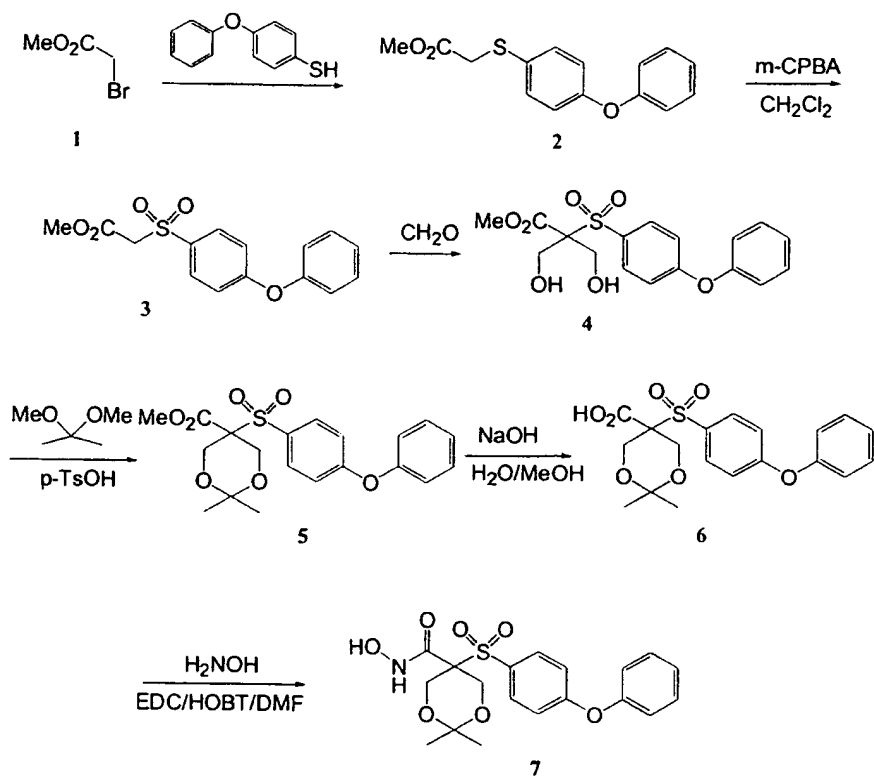
Scheme 3



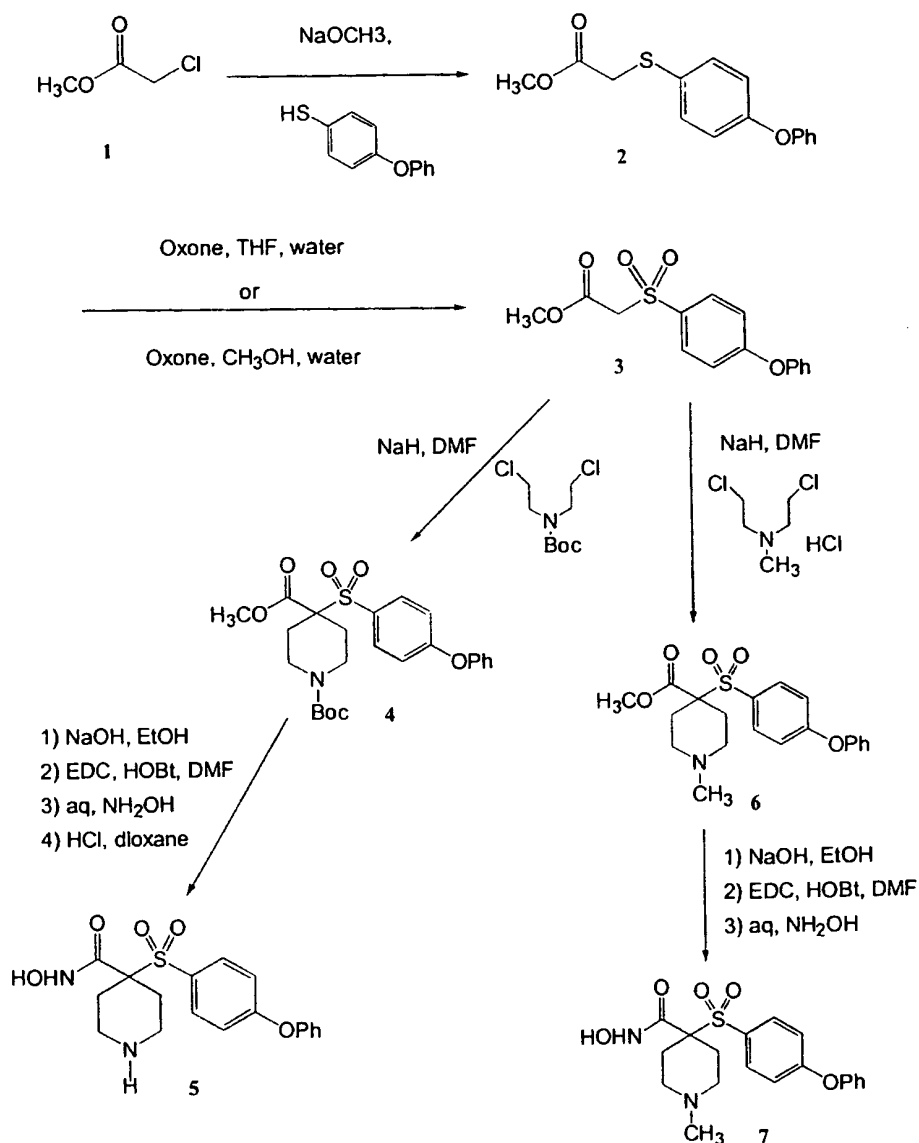
Scheme 4



Scheme 5

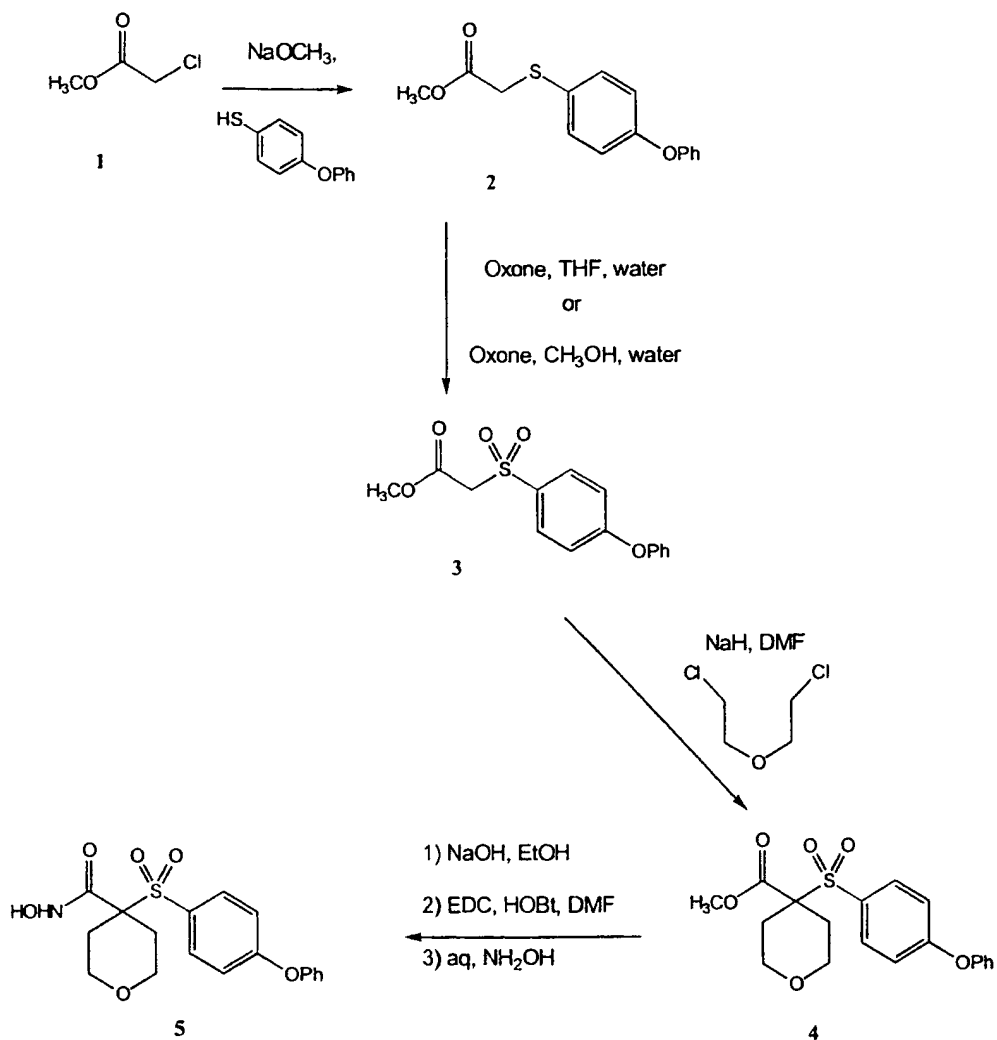


Scheme 6



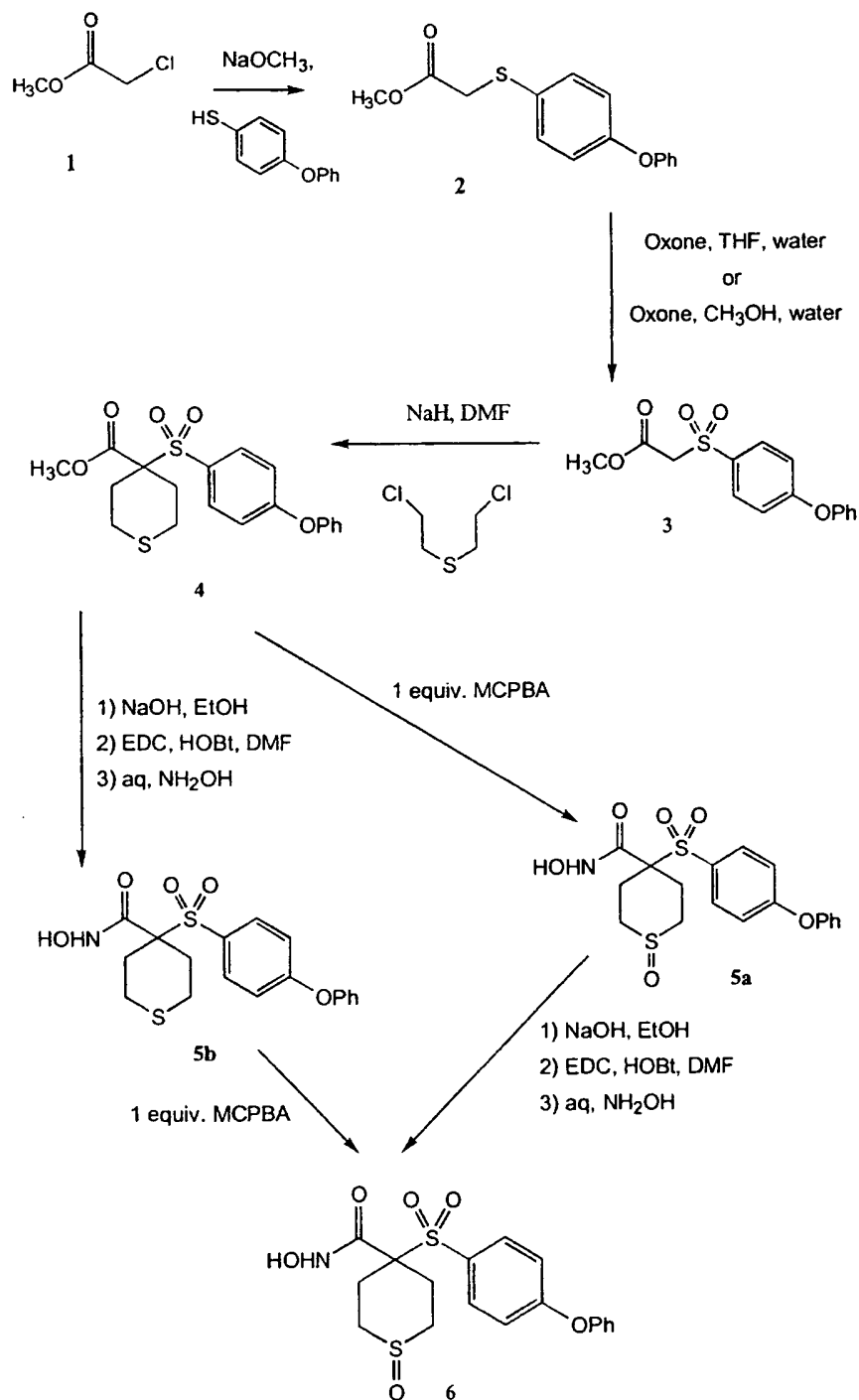
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Scheme 7



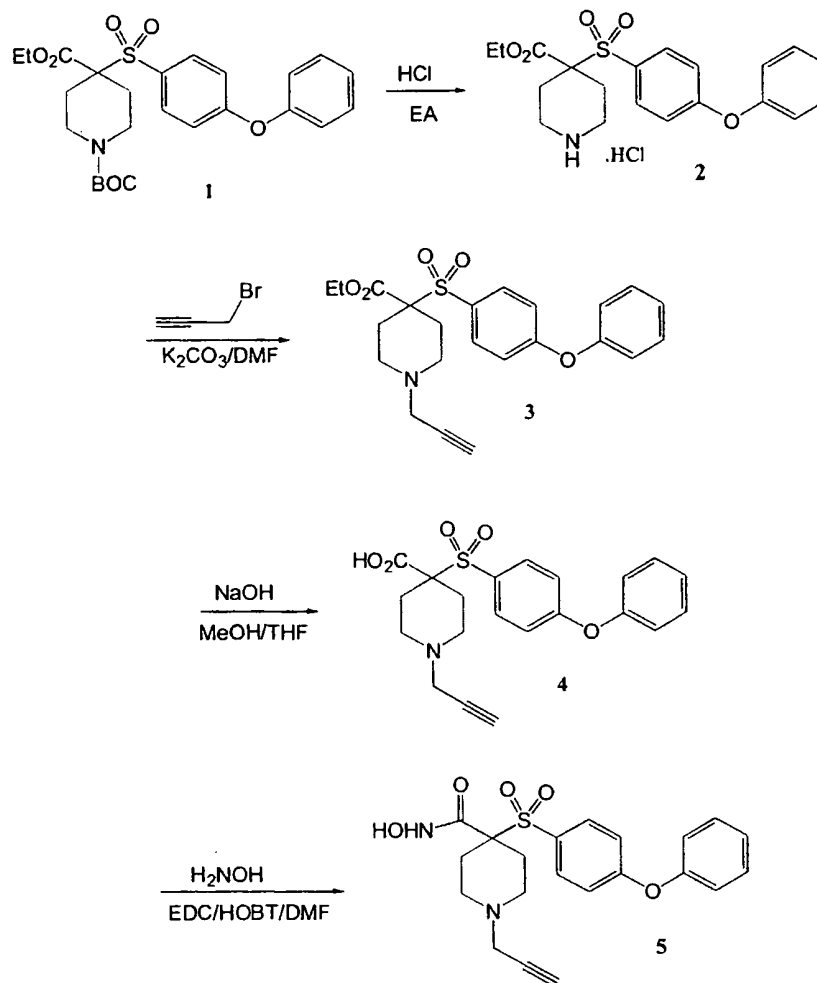
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Scheme 8



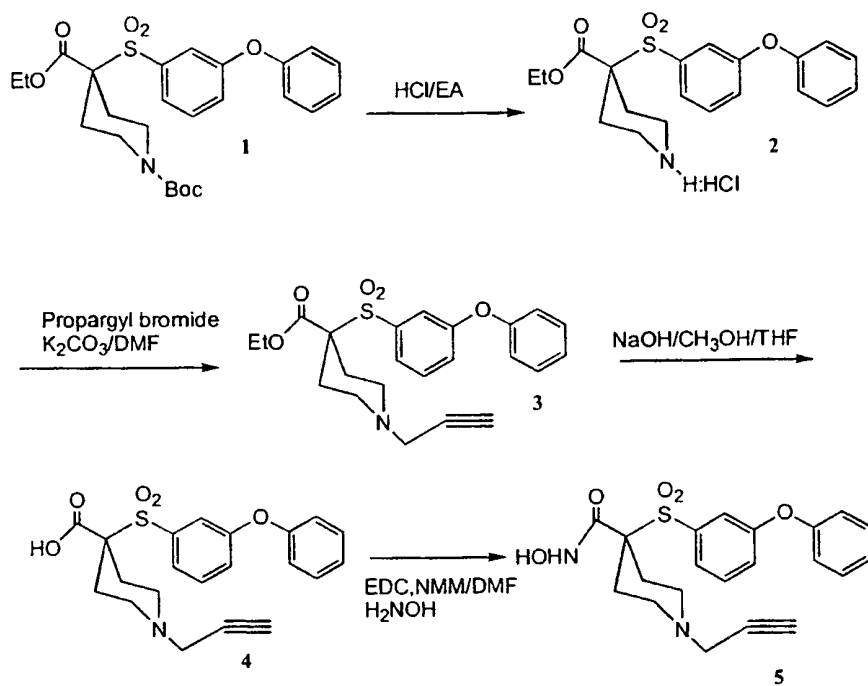
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Scheme 9

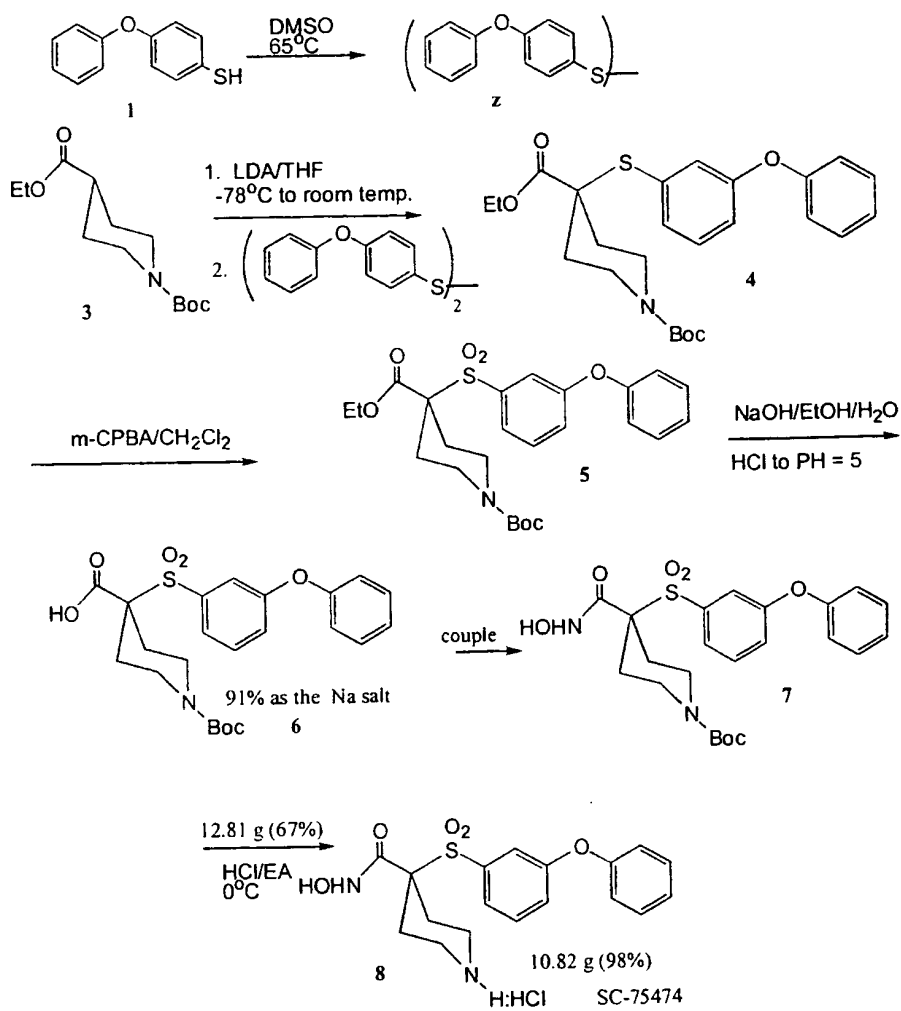


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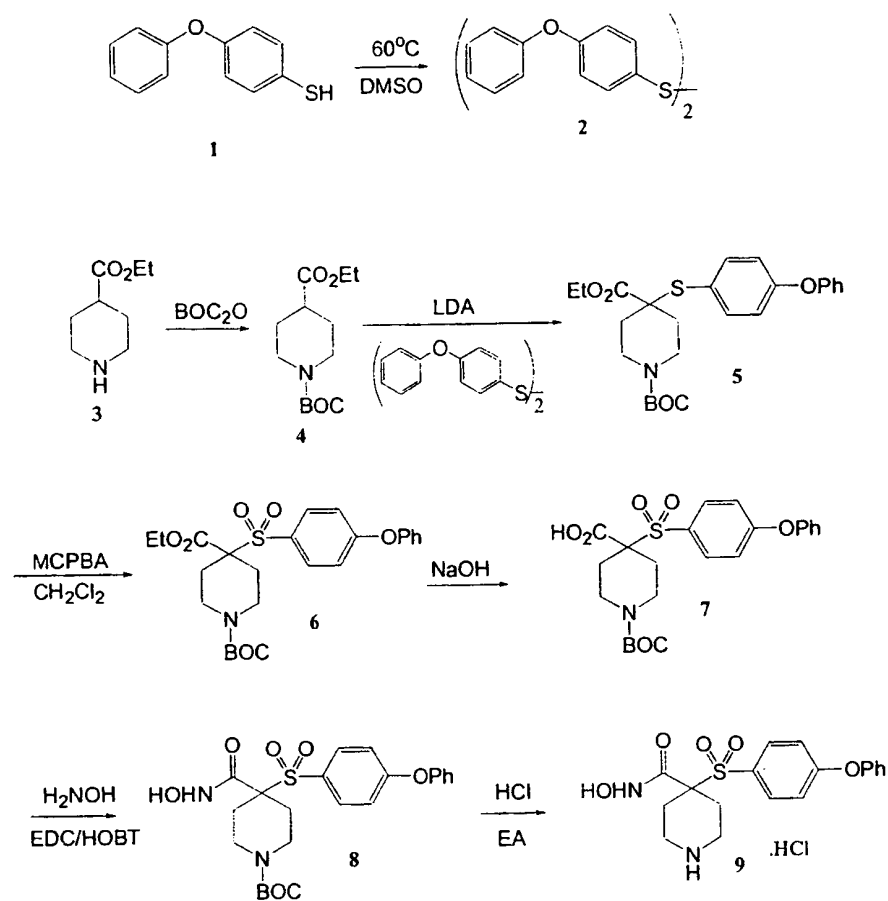
Scheme 10



Scheme 11

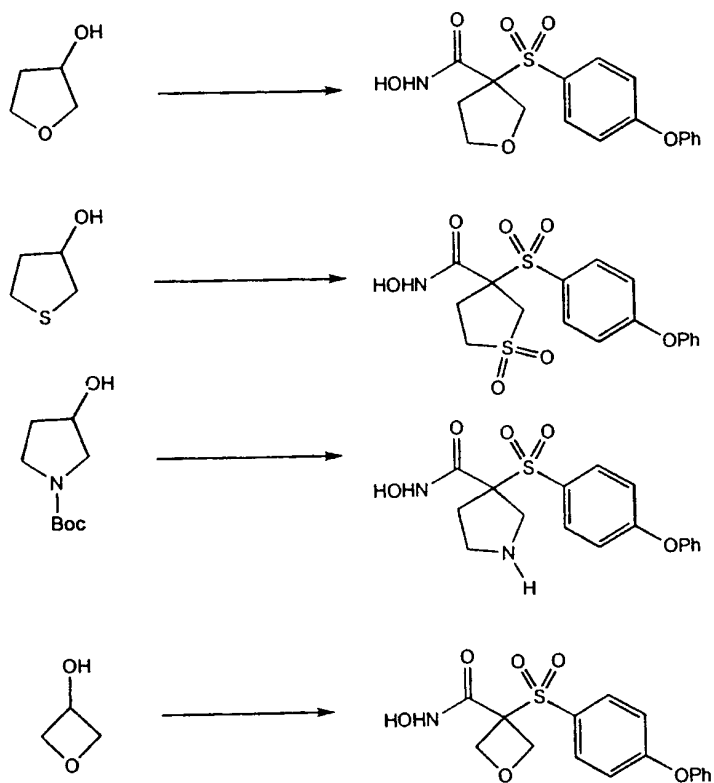


Scheme 12



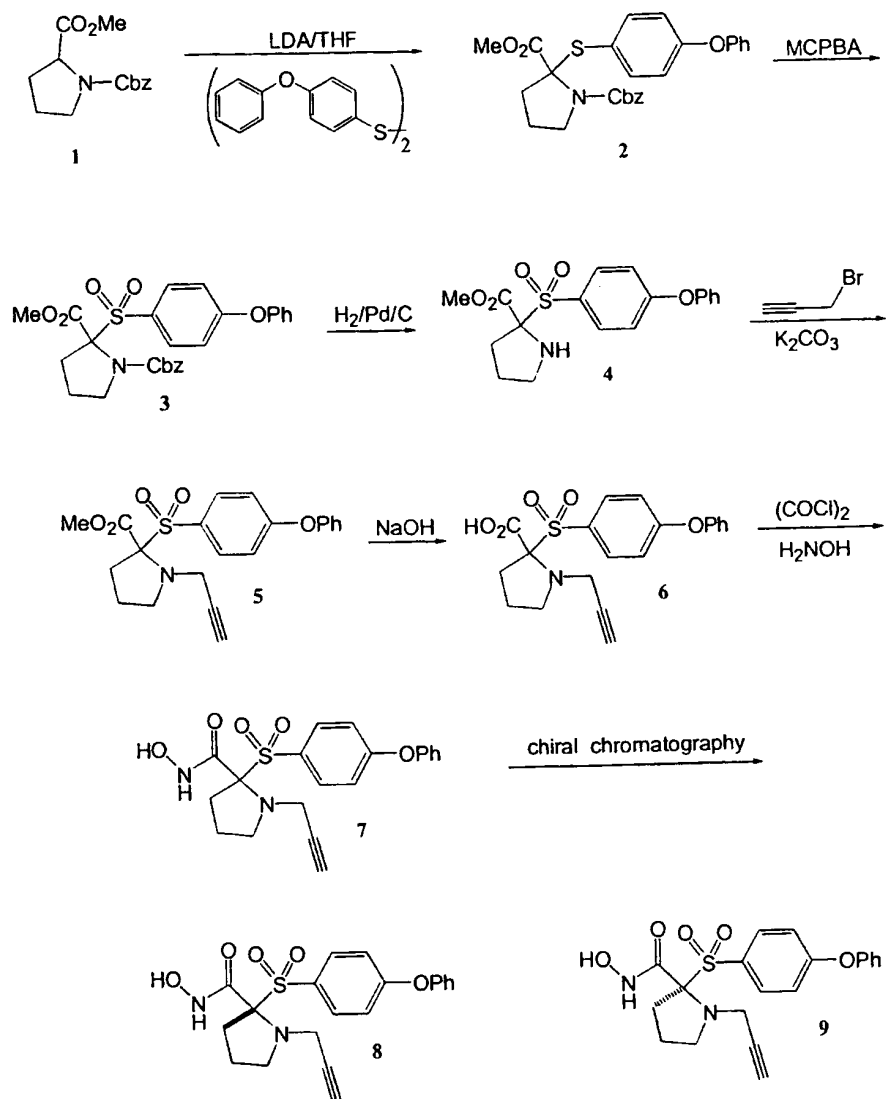
Scheme 13

In a similar manner, the following analogs can be made.

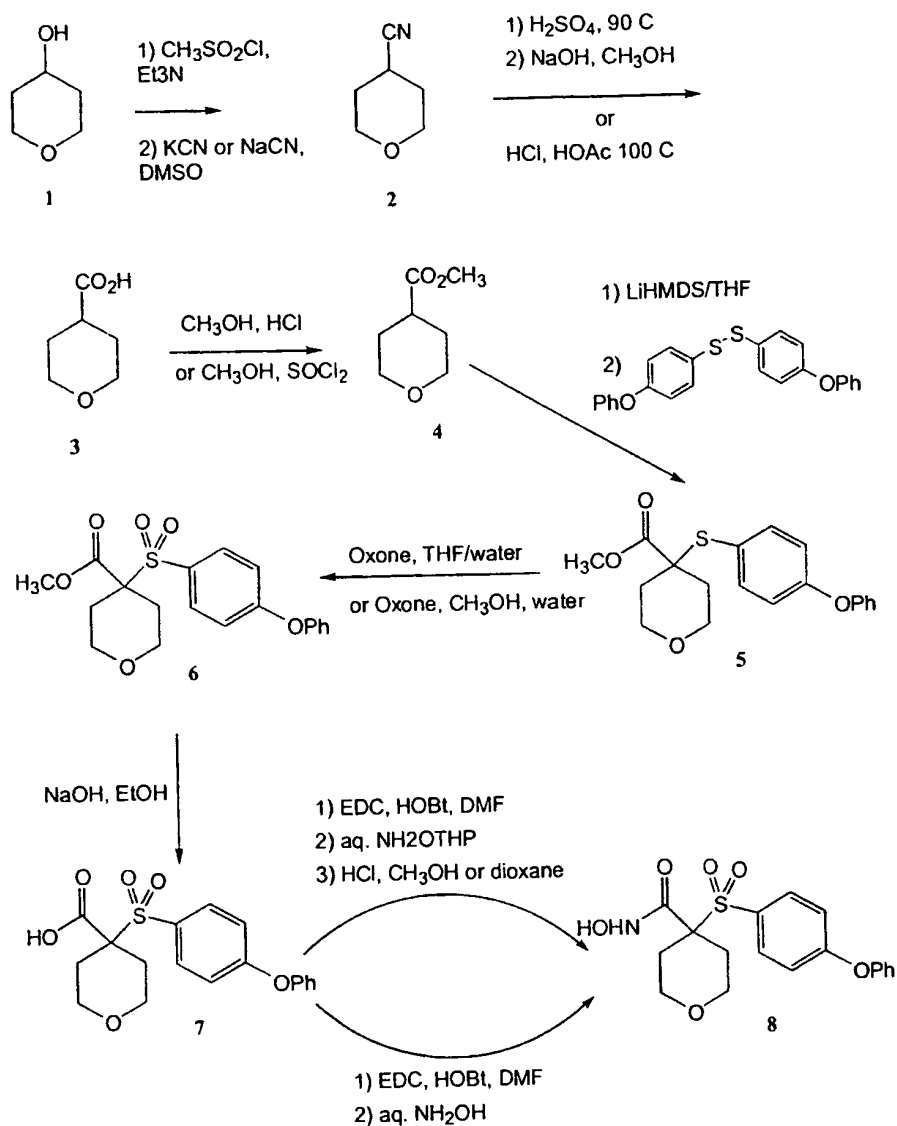


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Scheme 14

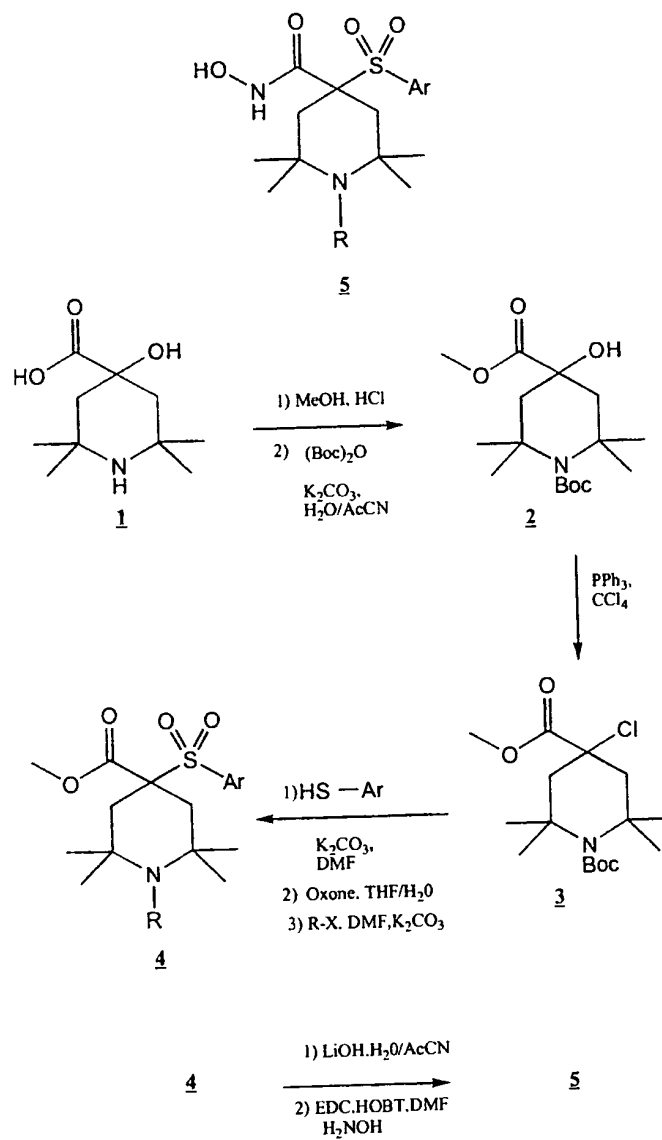


Scheme 15



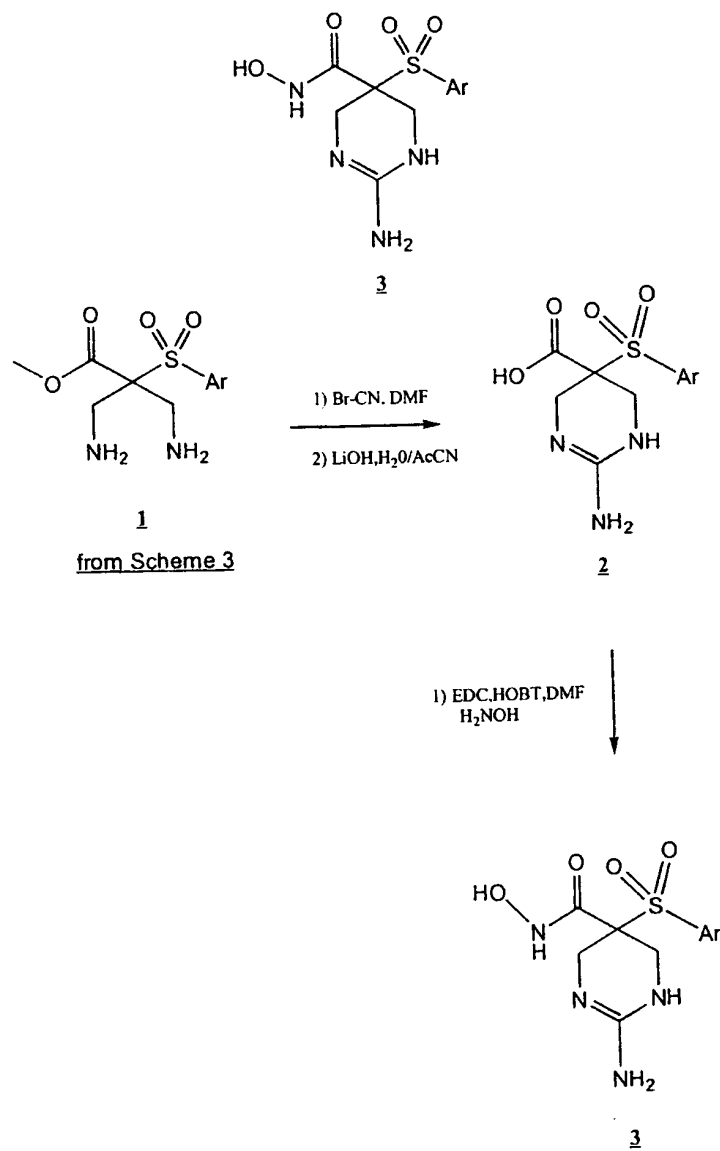
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Scheme 16

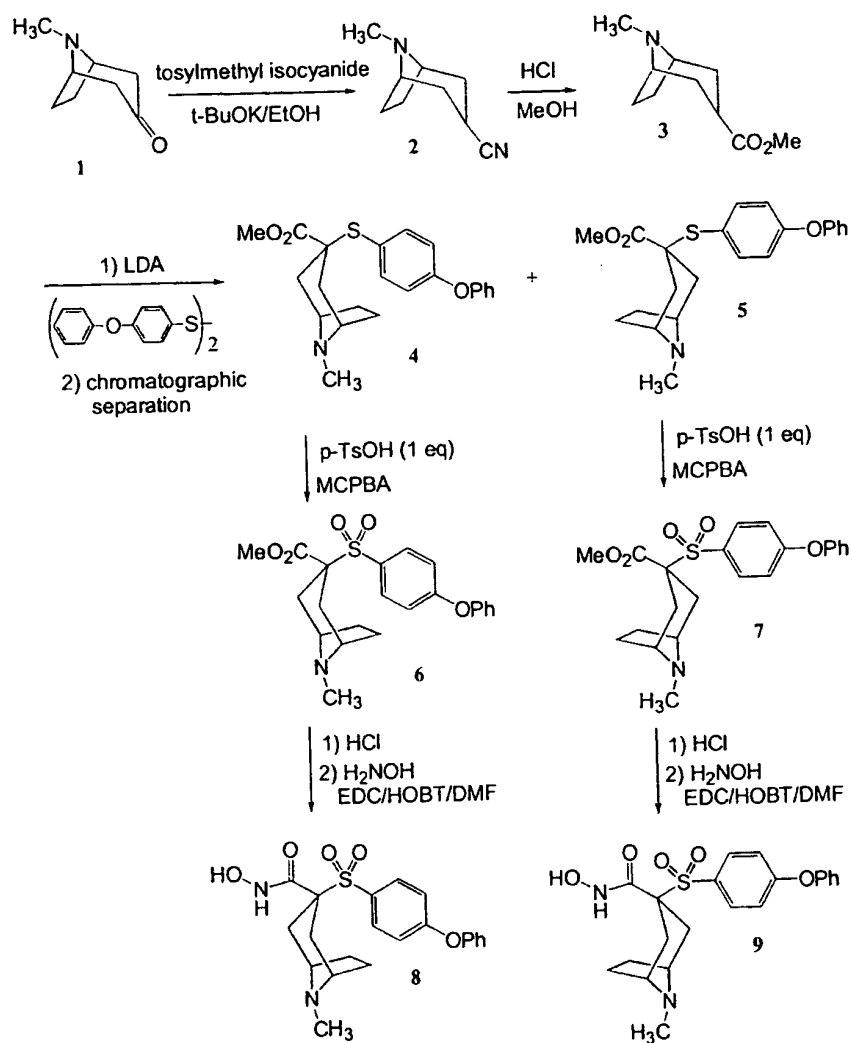


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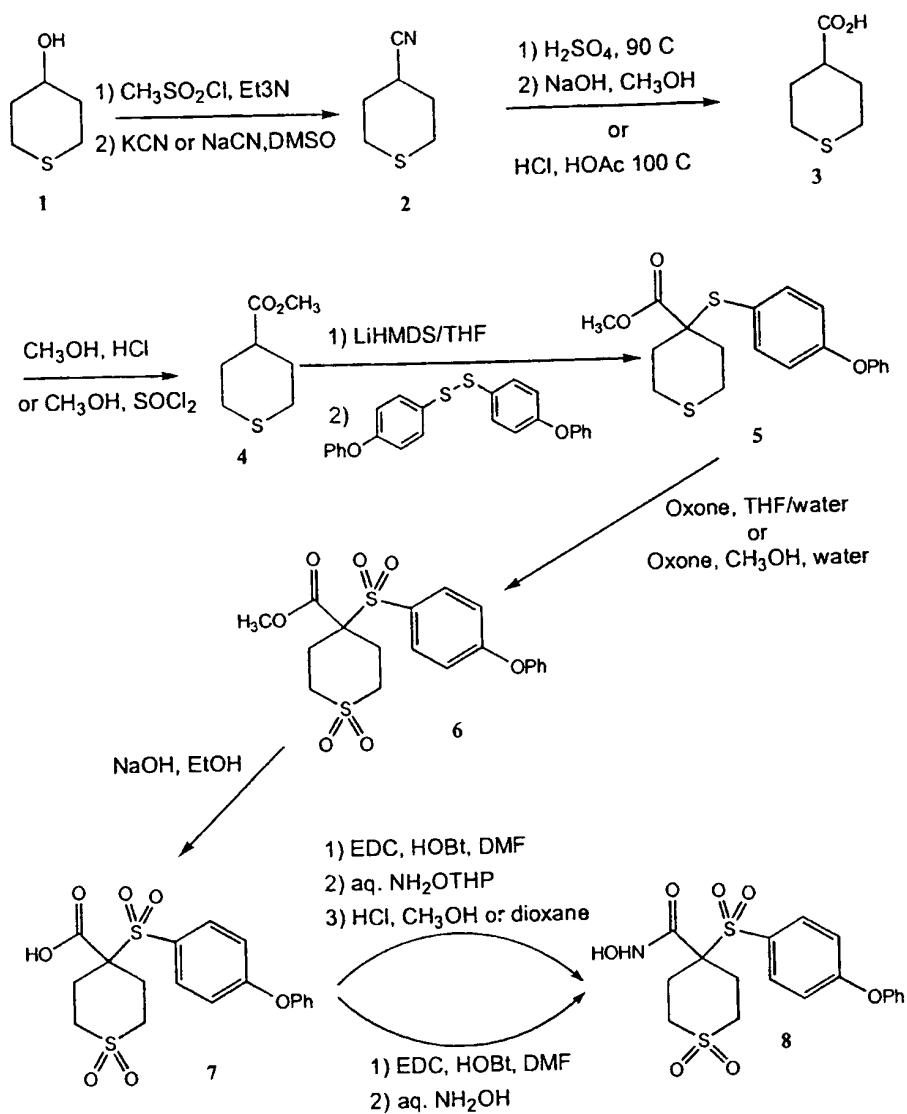
Scheme 17



Scheme 18



Scheme 19



5

Table 1 through Table 150, below, show several contemplated aromatic sulfone hydroxamic acid inhibitor compounds or structural formulas that illustrate substituent groups. Each group of

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compounds is illustrated by a generic formula, or formulae, followed by a series of preferred moieties or groups that constitute various substituents that can be attached at the position clearly shown in the generic structure. The substituent symbols, e.g., R1 and R2 and R3, are as shown in each Table, and are typically not those used before. One or two bonds (wavy lines) are shown with those substituents to indicate the respective positions of attachment in the illustrated compound. This system is well known in the chemical communication arts and is widely used in scientific papers and presentations. For example in Table 2, R1 and R2 together with the atoms to which they are bonded is the variable group with the structural entities that can substitute for R1 and R2 together shown in the balance of that table.

20

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Table 1

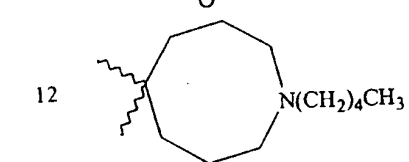
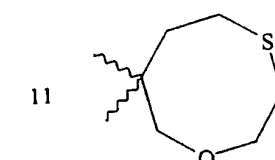
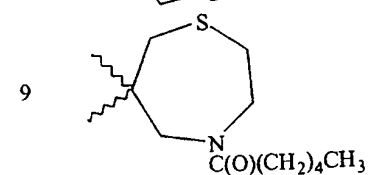
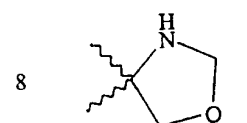
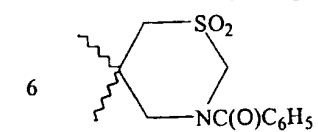
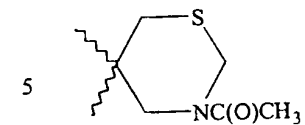
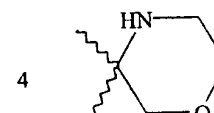
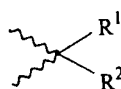
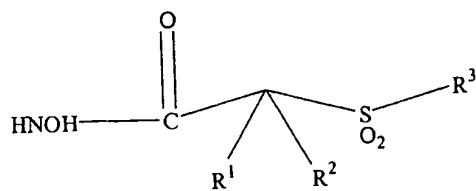
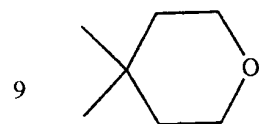
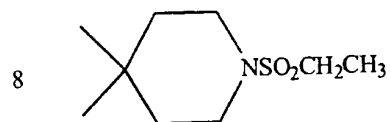
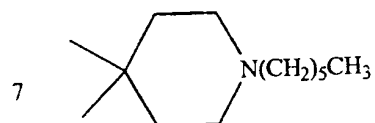
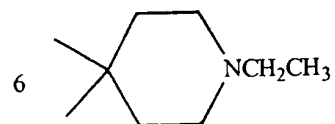
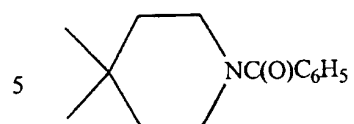
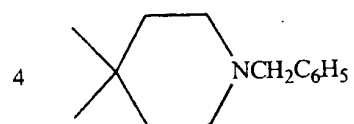
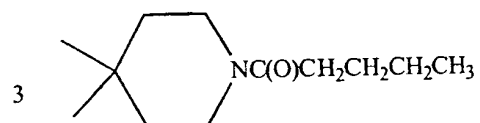
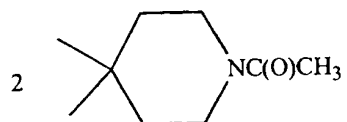
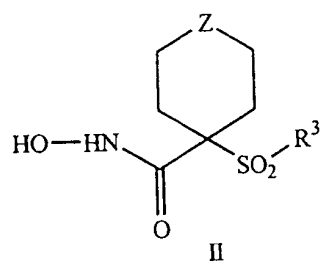
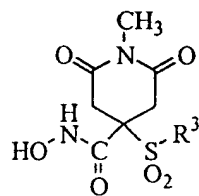
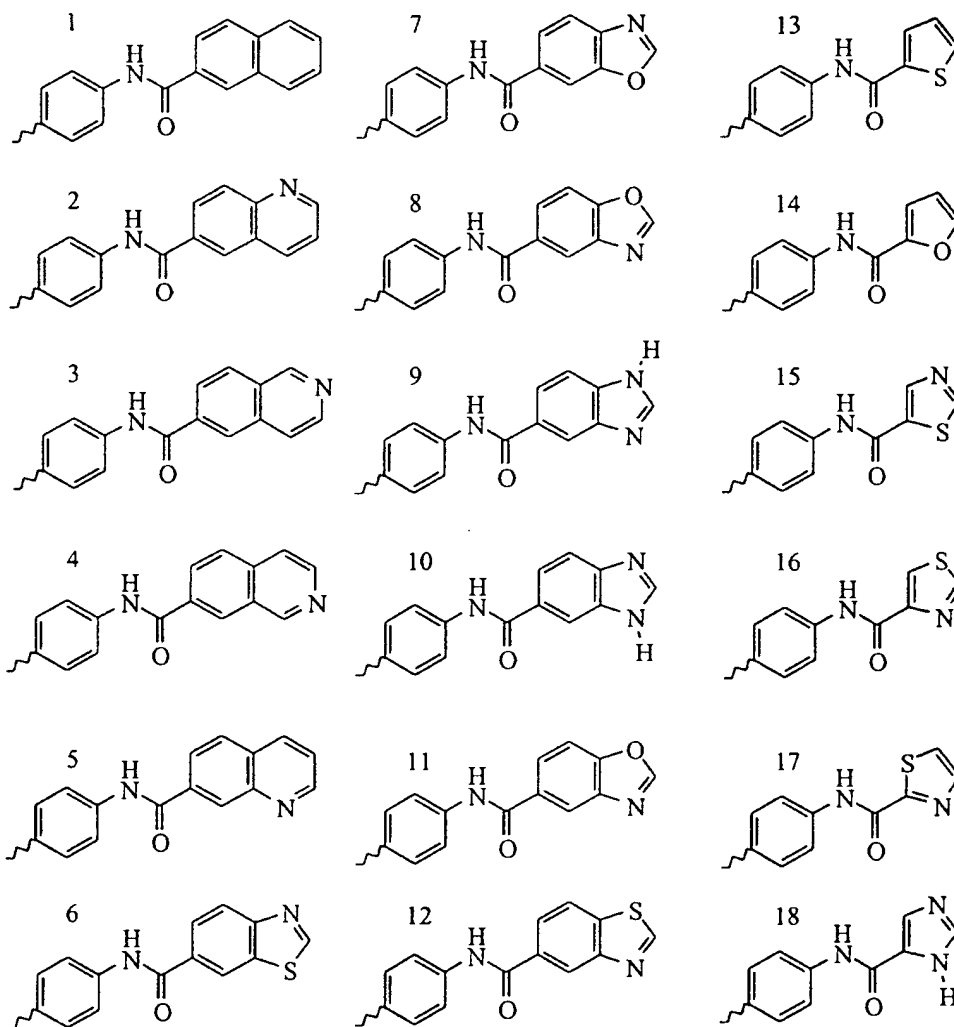


Table 2



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Table 3

 R^3 

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Table 4

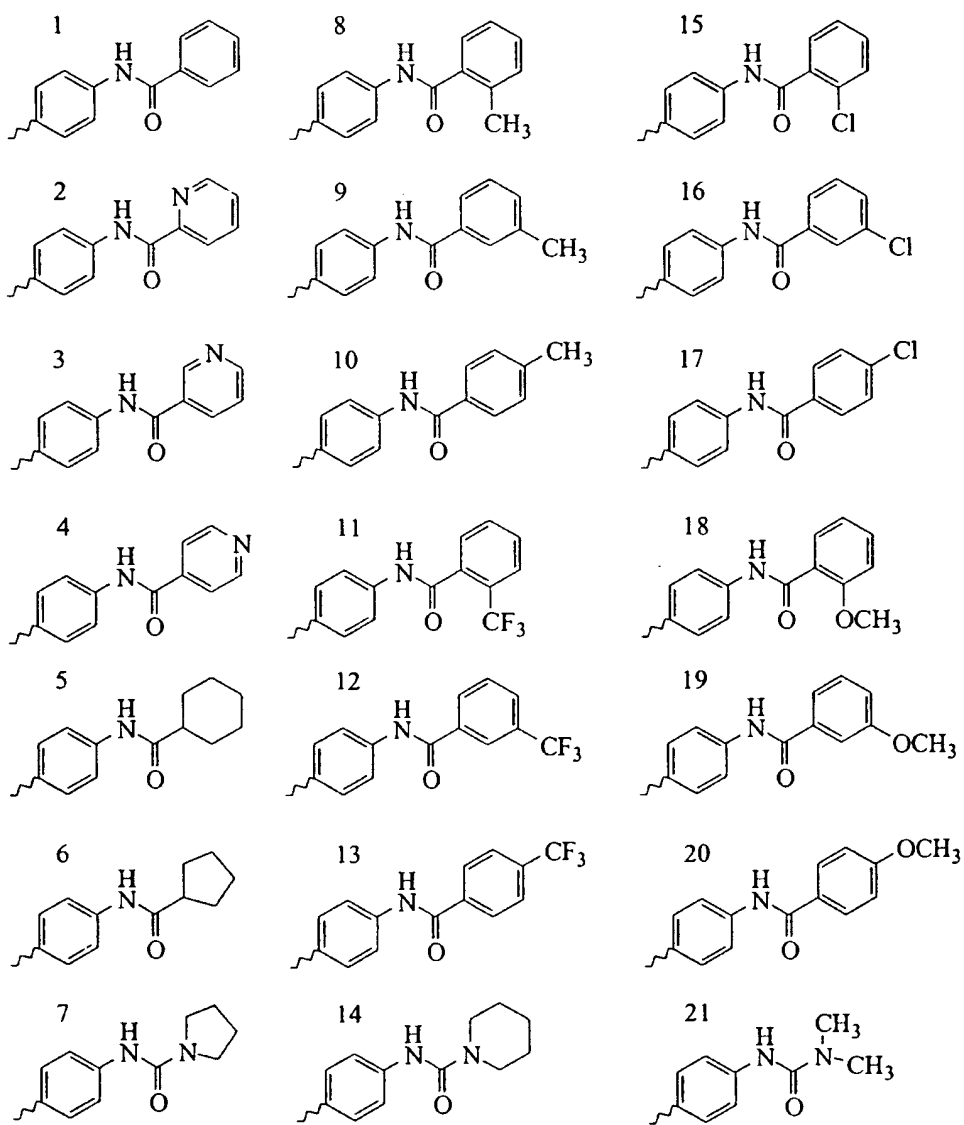
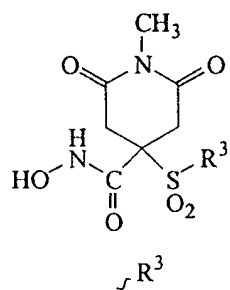
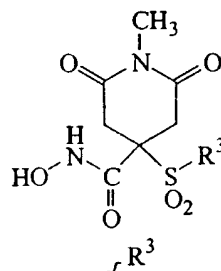


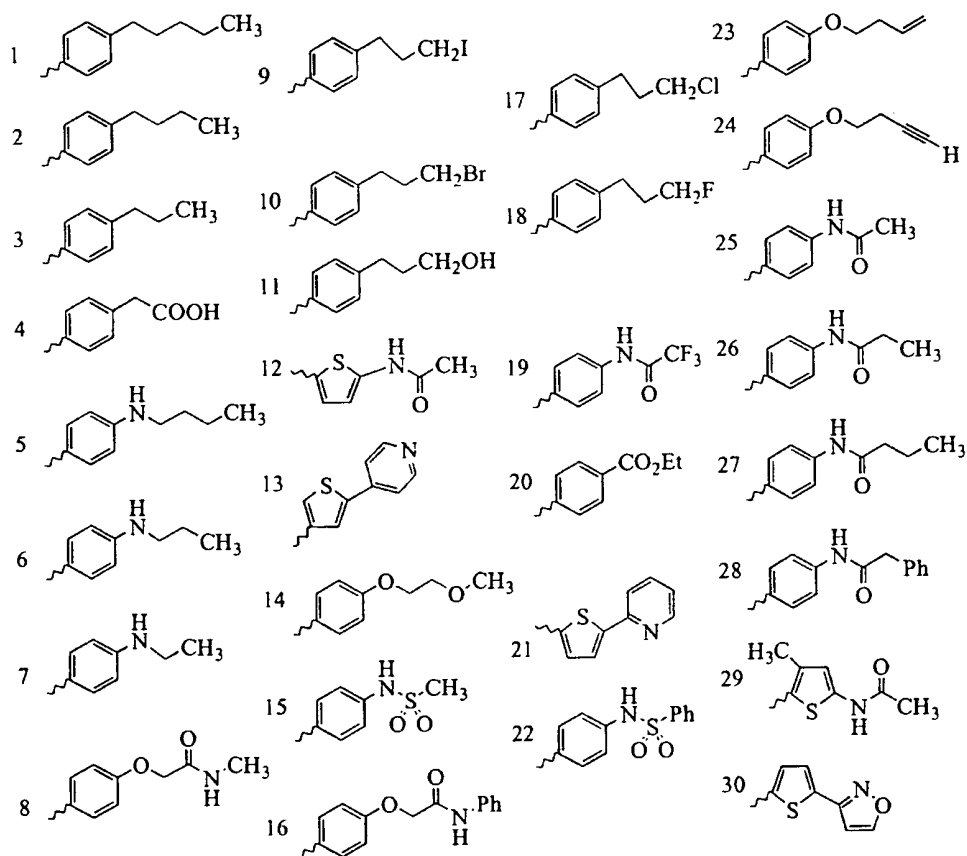
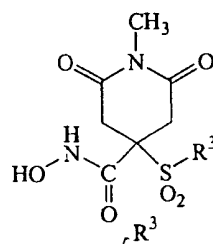
Table 5



1 	9 	16
2 	10 	17
3 	11 	18
4 	12 	19
5 	13 	20
6 	14 	21
7 	15 	22
8 		

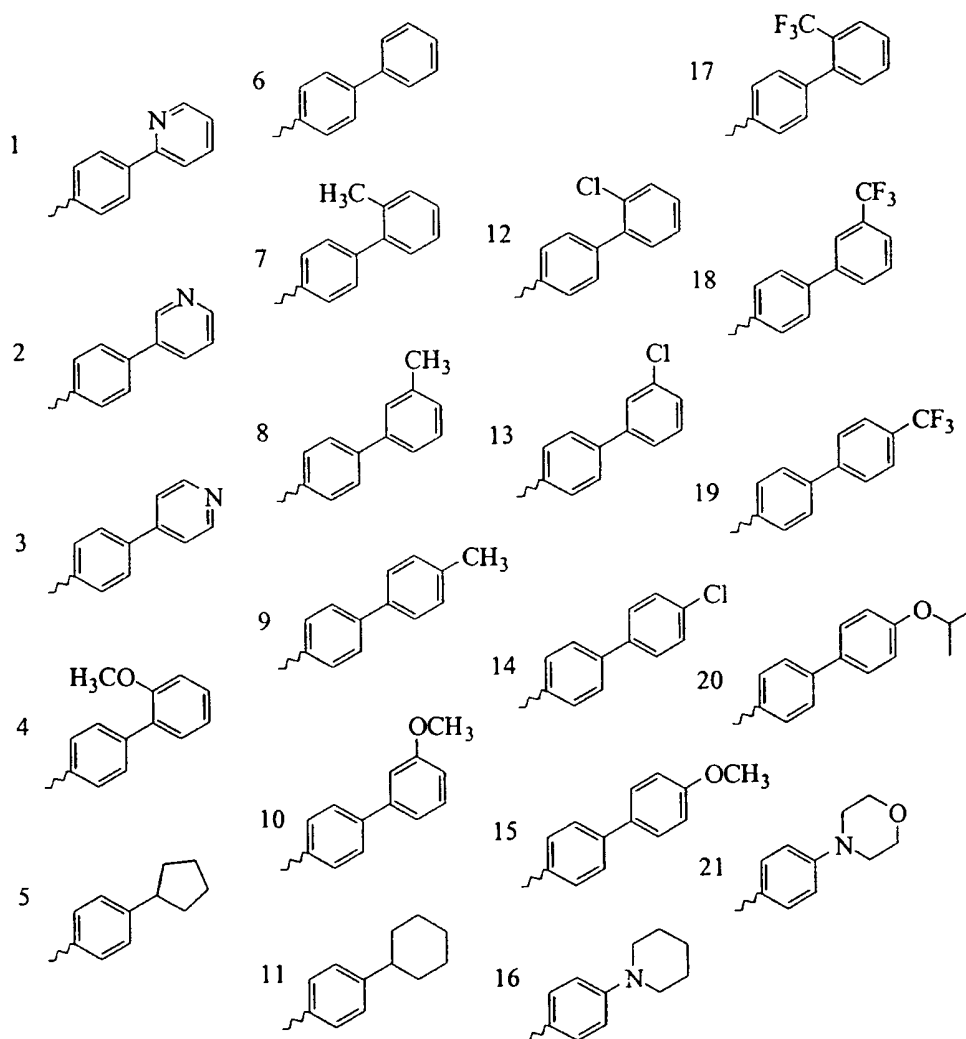
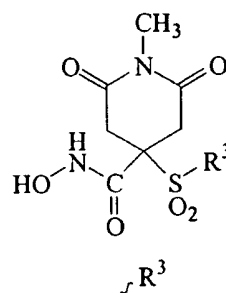
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Table 6



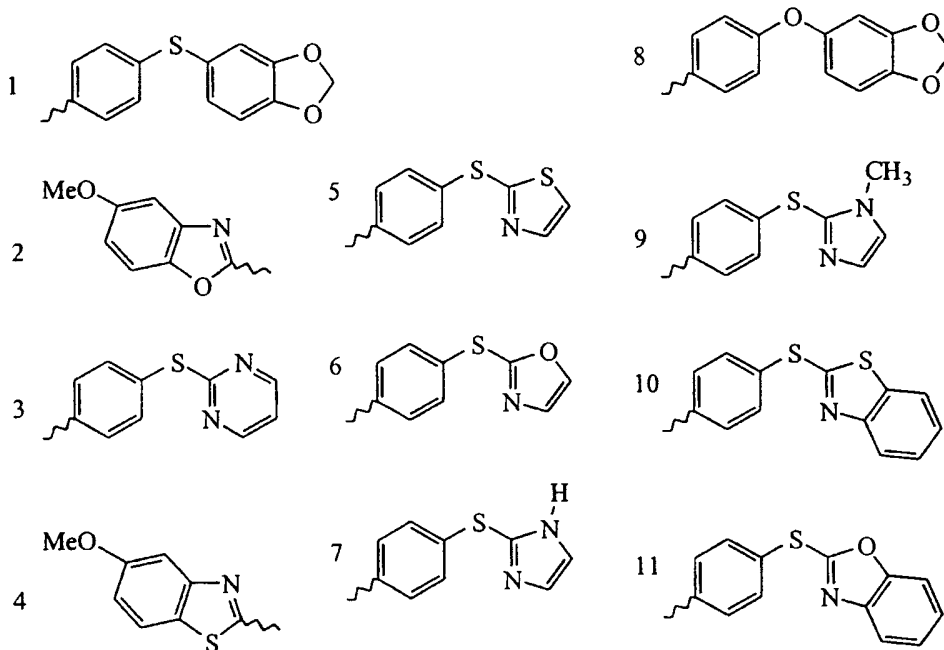
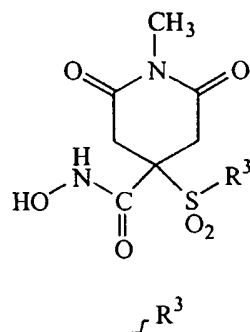
- 136 -

Table 7



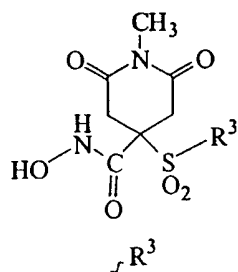
- 137 -

Table 8



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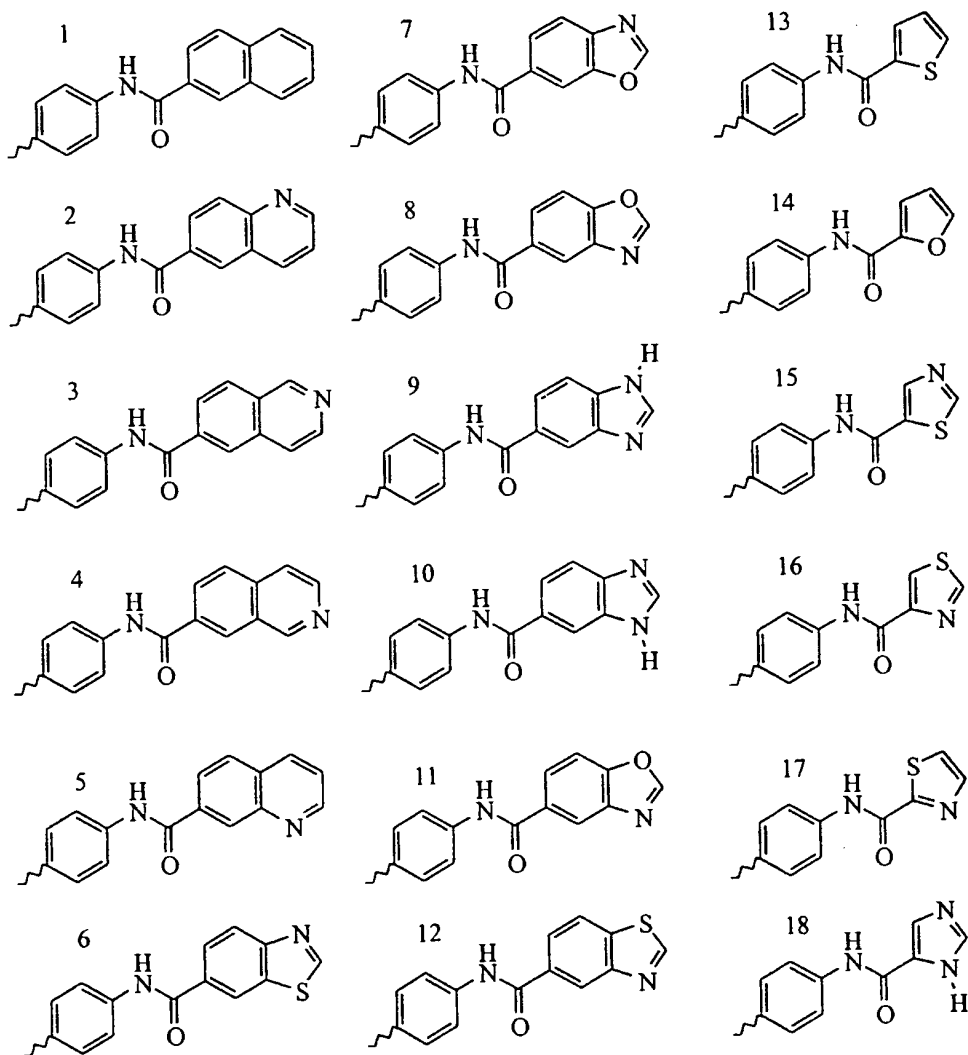
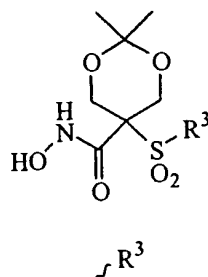
Table 9



1 	8 	15
2 	9 	16
3 	10 	17
4 	11 	18
5 	12 	19
6 	13 	20
7 	14 	21

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Table 10



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Table 11

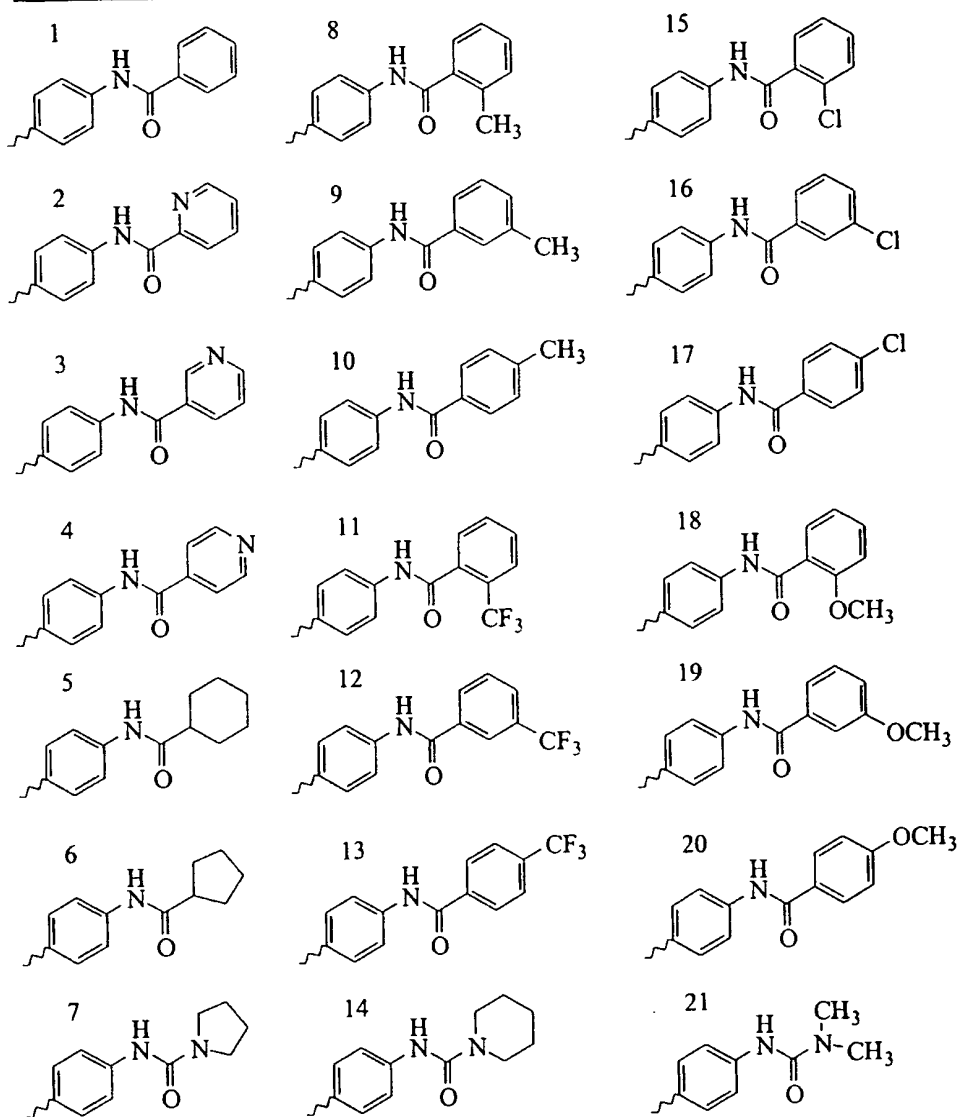
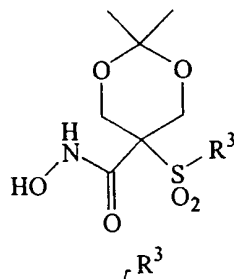
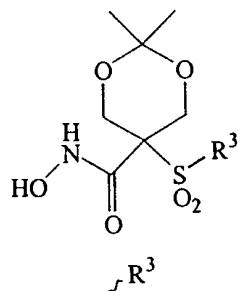


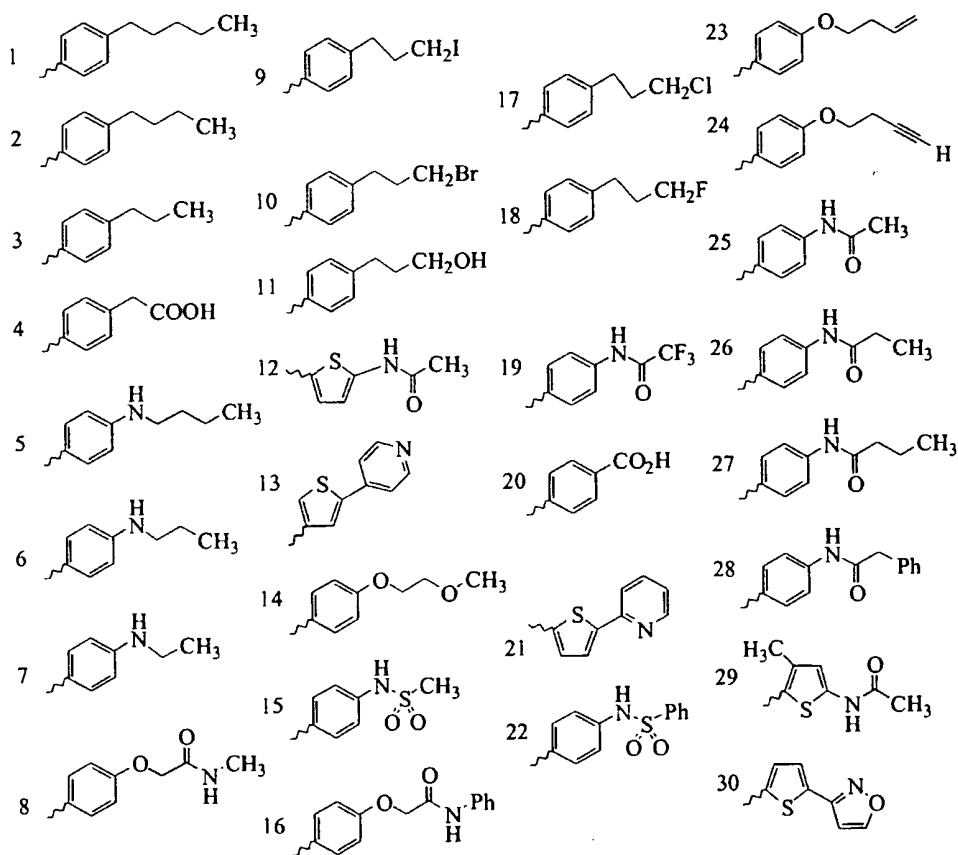
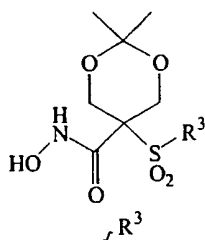
Table 12



1 	9 	16
2 	10 	17
3 	11 	18
4 	12 	19
5 	13 	20
6 	14 	21
7 	15 	22
8 		

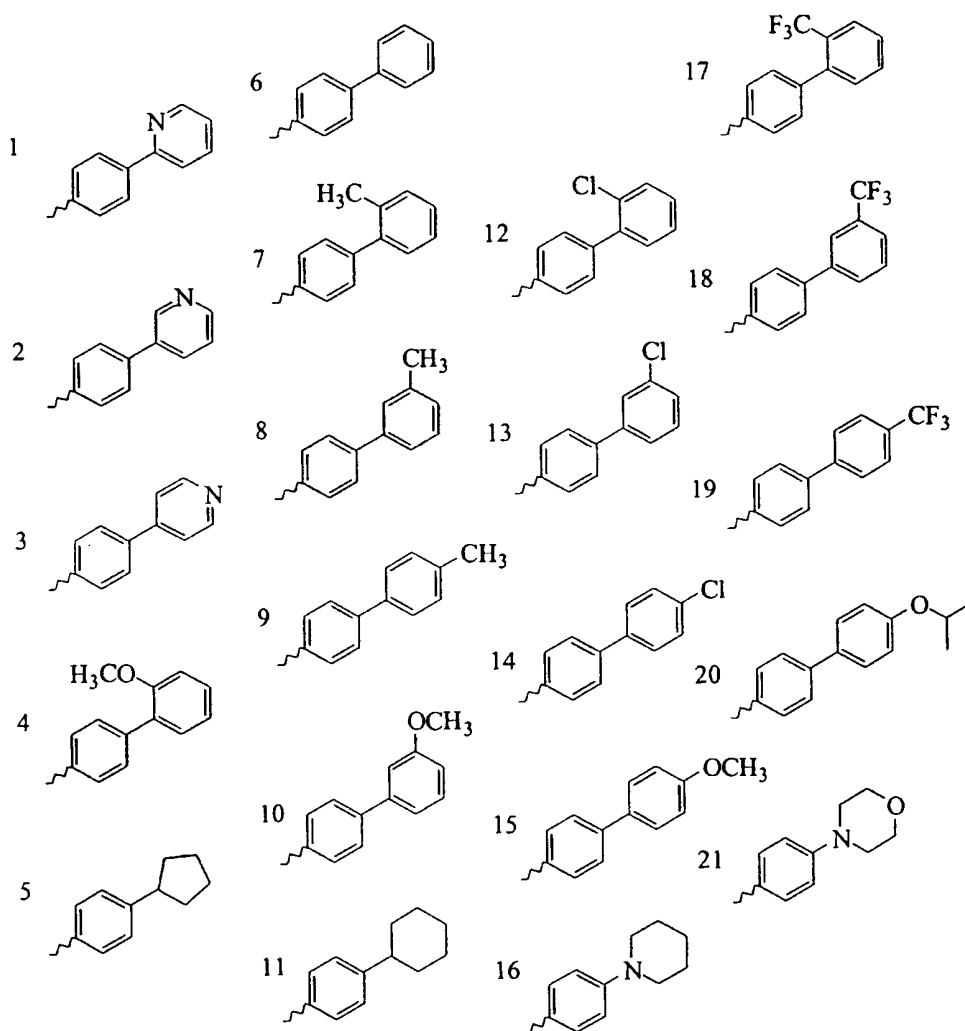
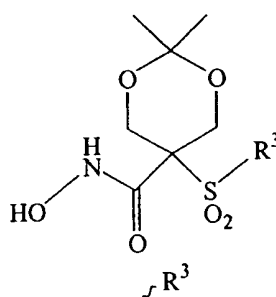
- 142 -

Table 13



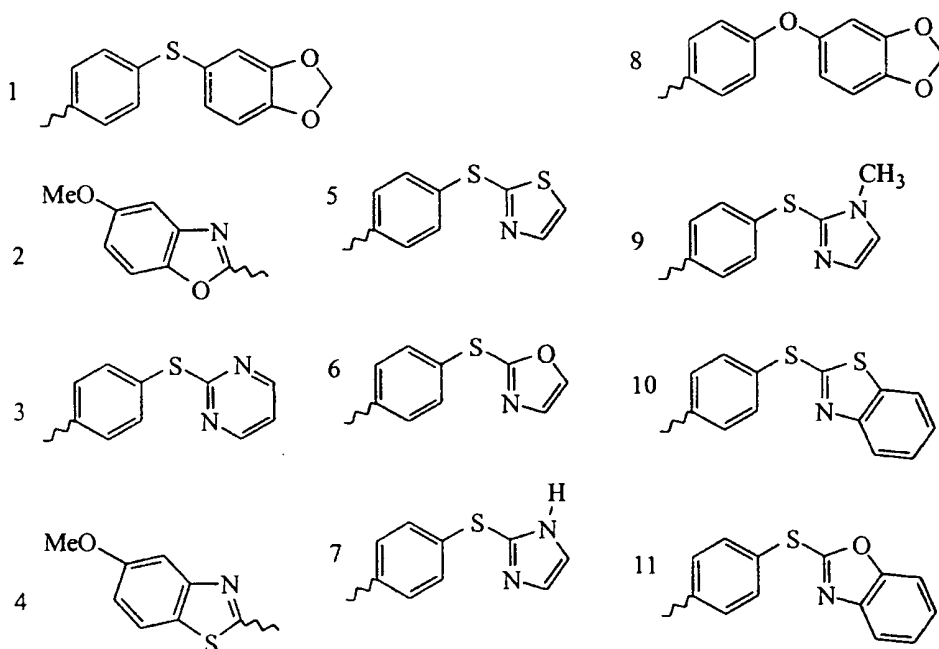
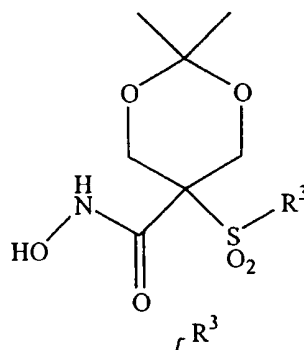
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Table 14



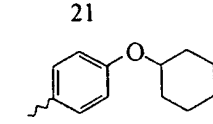
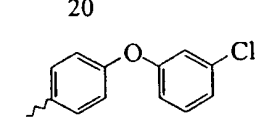
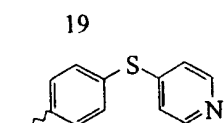
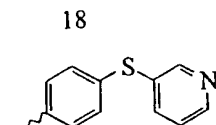
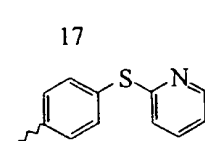
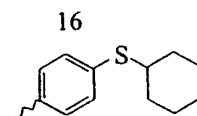
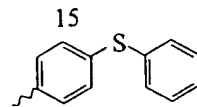
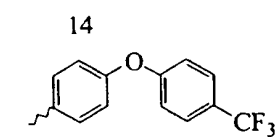
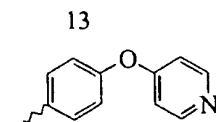
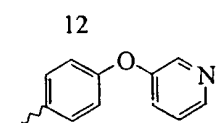
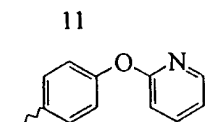
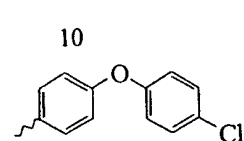
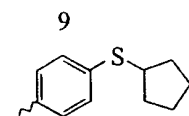
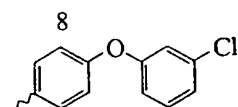
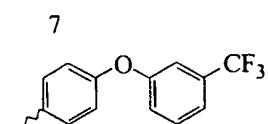
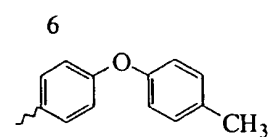
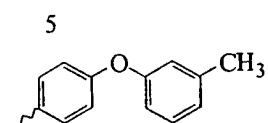
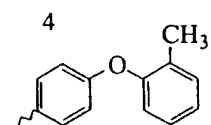
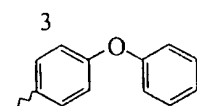
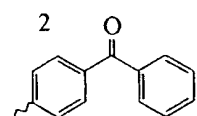
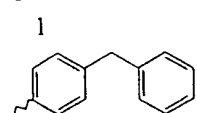
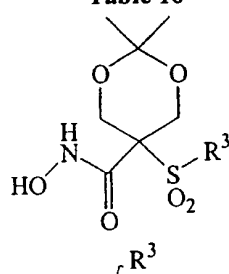
- 144 -

Table 15



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Table 16



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Table 17

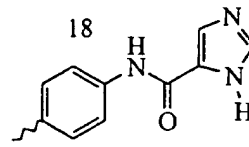
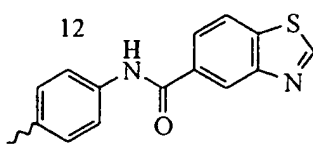
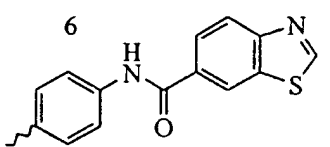
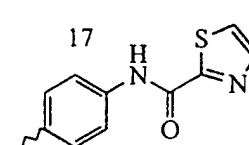
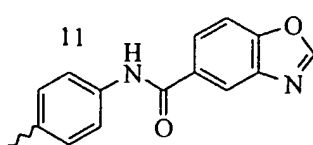
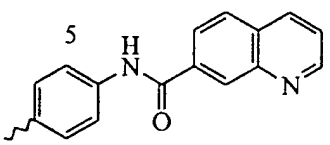
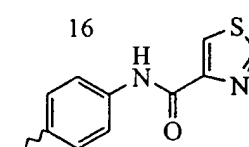
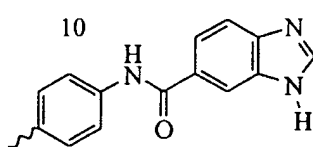
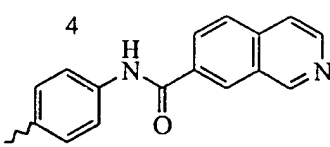
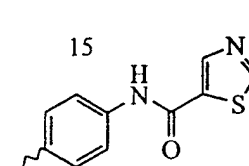
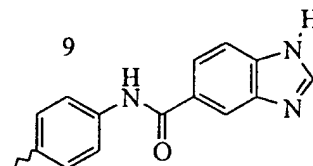
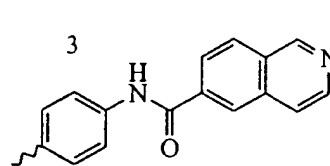
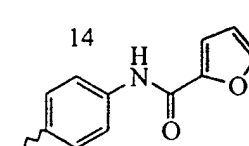
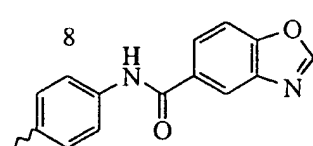
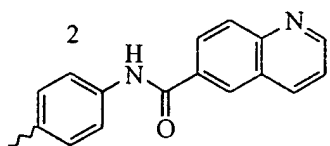
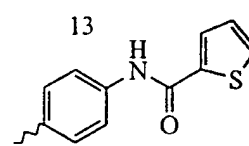
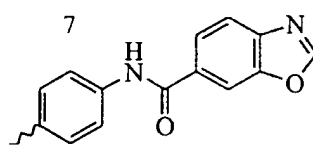
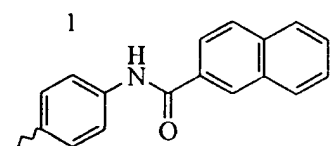
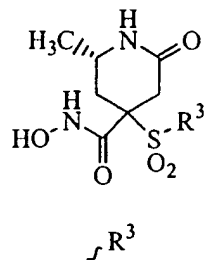


Table 18

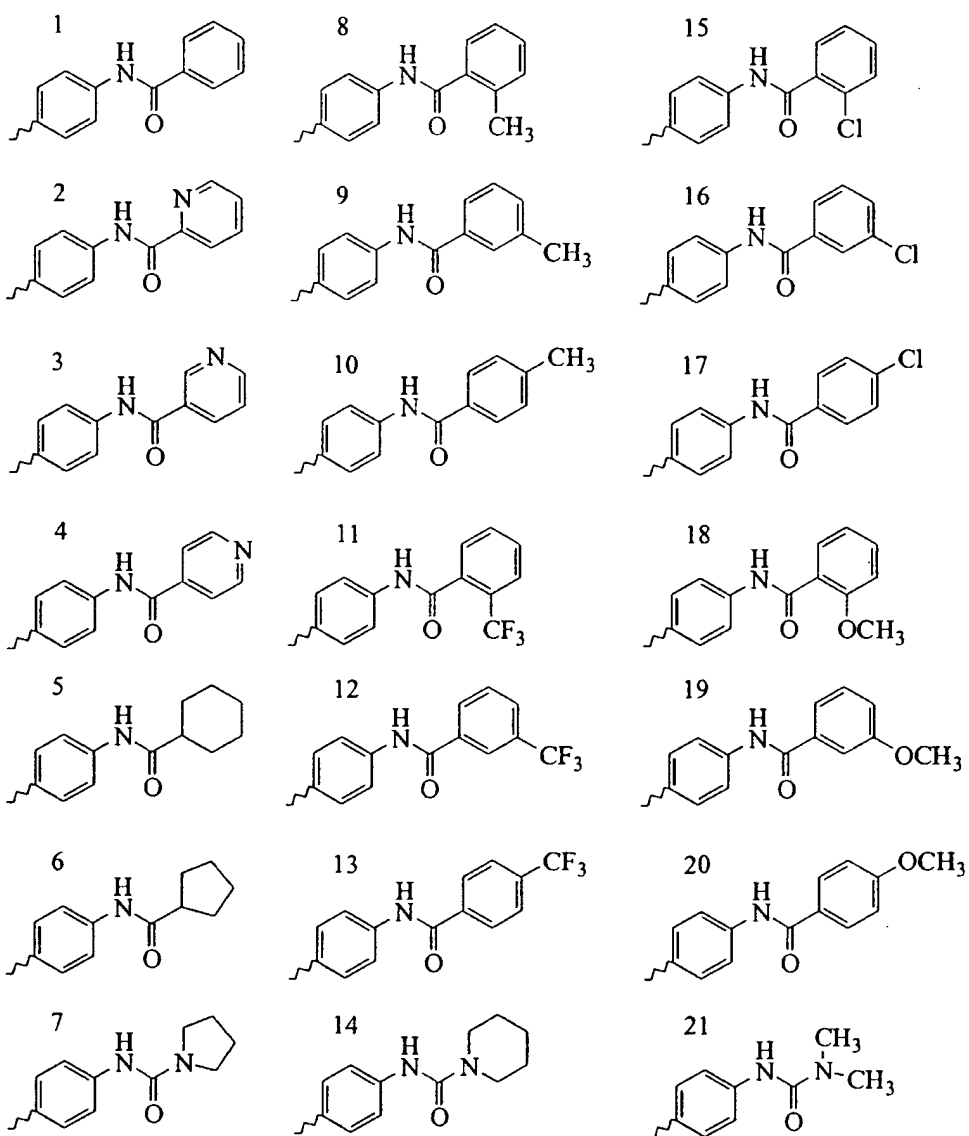
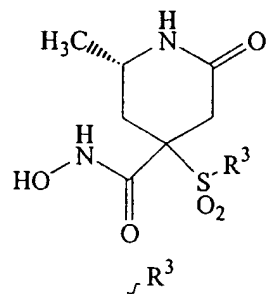
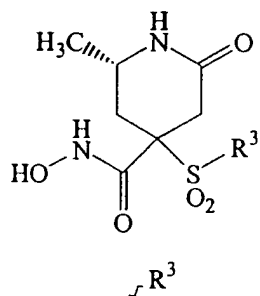


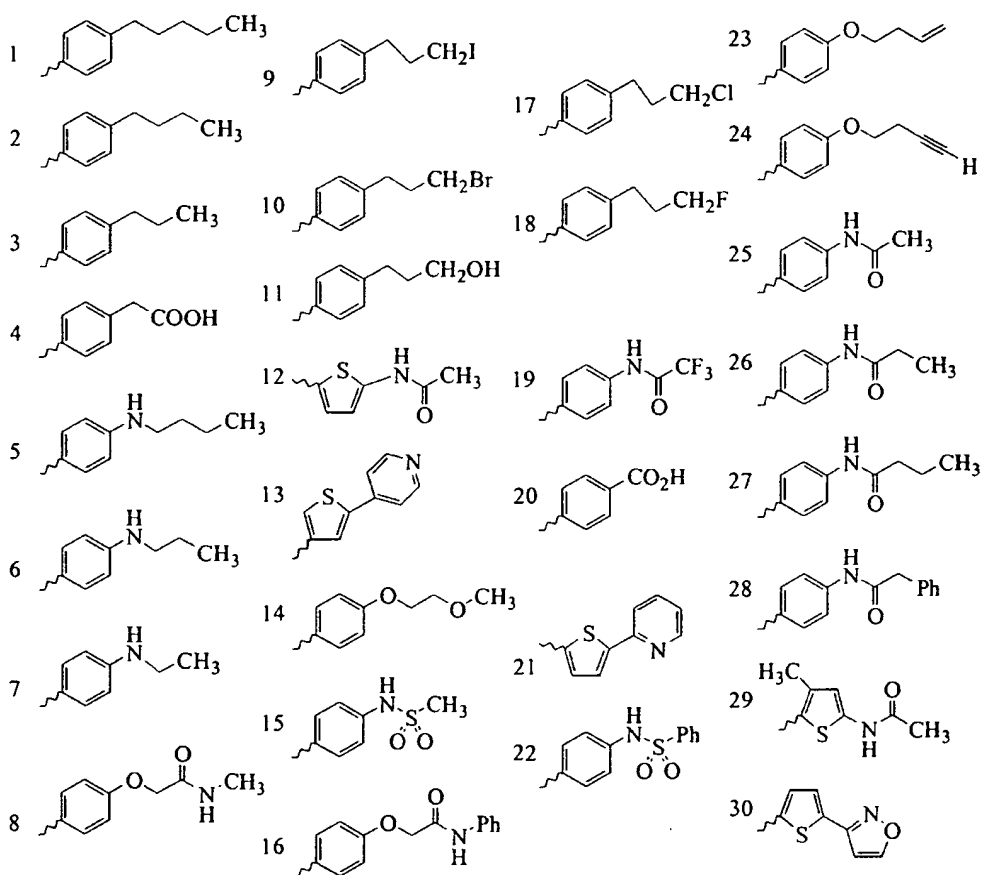
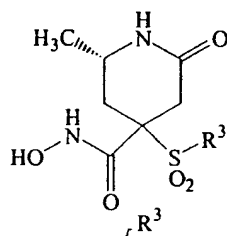
Table 19



1 	9 	16
2 	10 	17
3 	11 	18
4 	12 	19
5 	13 	20
6 	14 	21
7 	15 	22
8 		

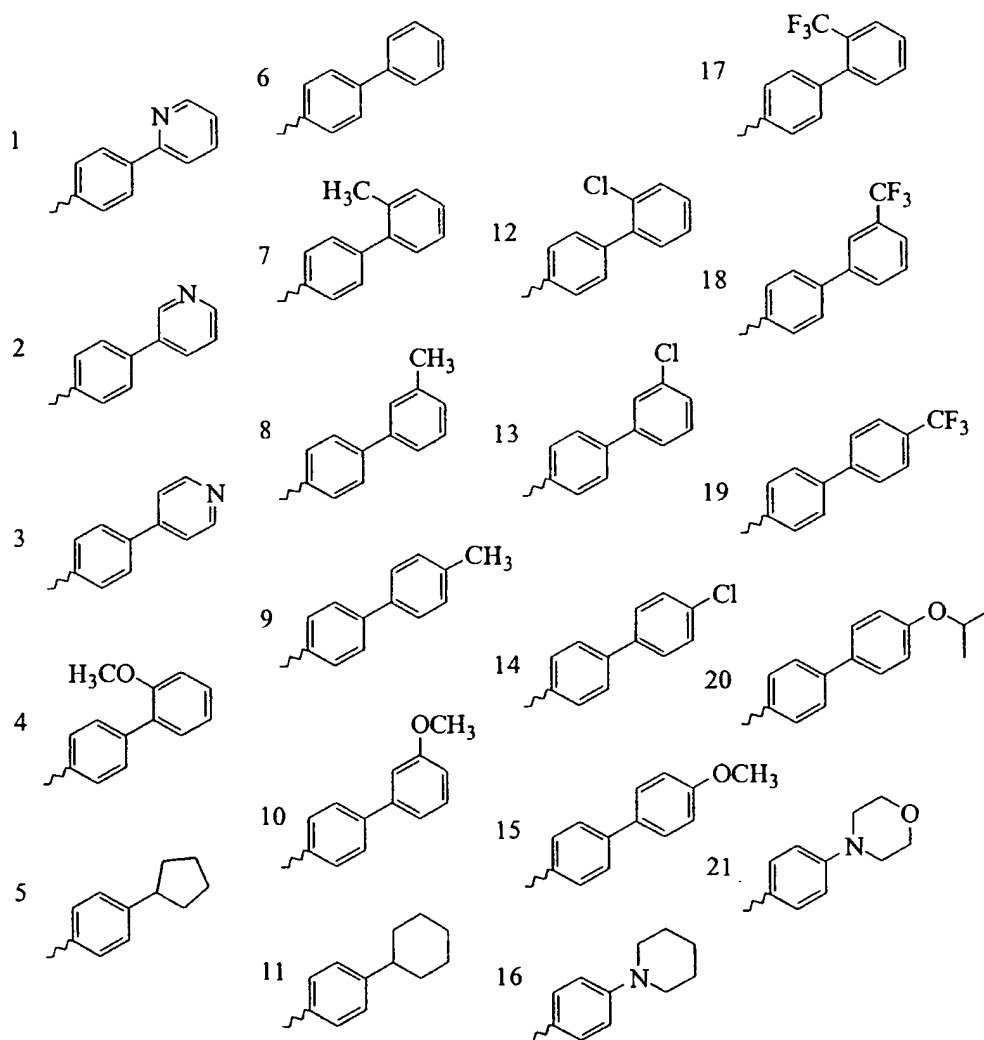
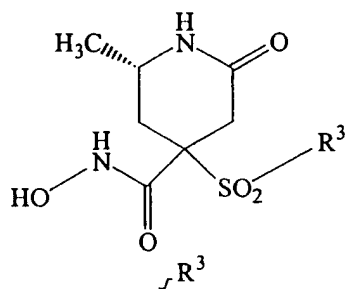
- 149 -

Table 20



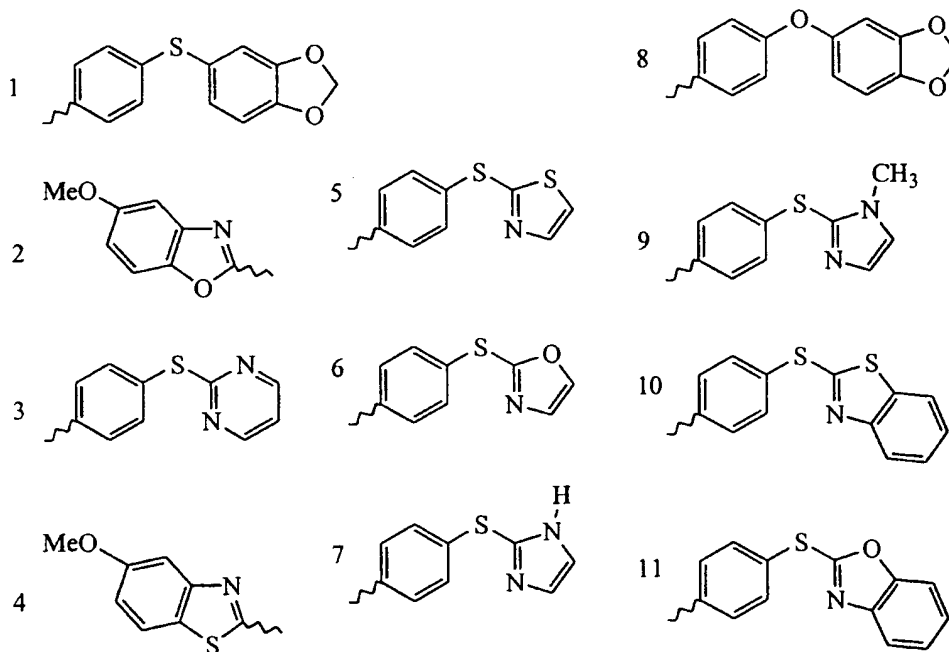
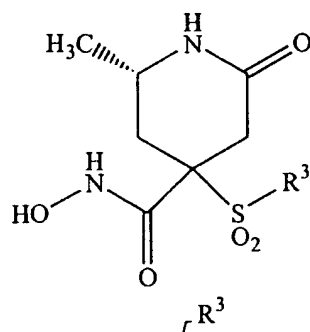
-150-

Table 21



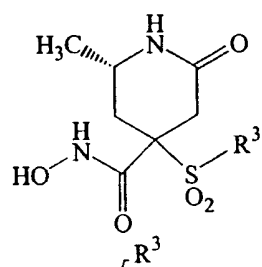
- 151 -

Table 22



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Table 23



1 	8 	15
2 	9 	16
3 	10 	17
4 	11 	18
5 	12 	19
6 	13 	20
7 	14 	21

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Table 24

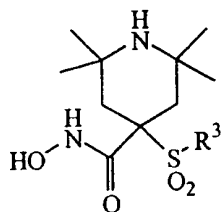
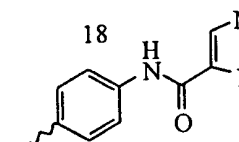
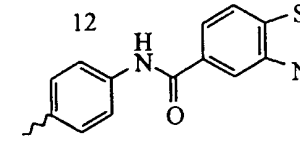
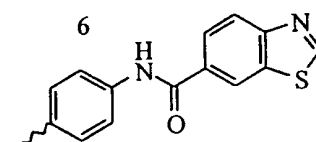
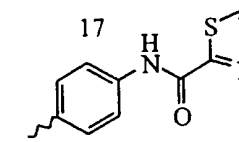
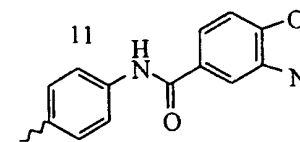
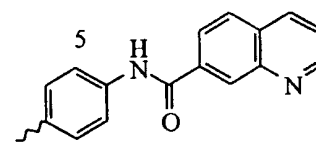
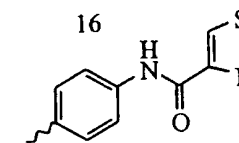
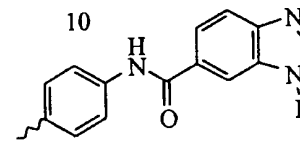
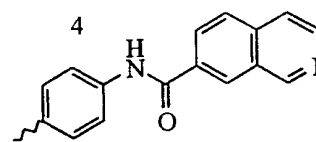
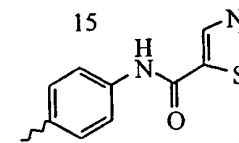
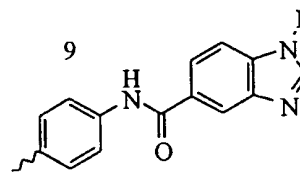
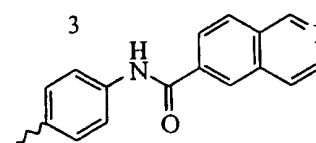
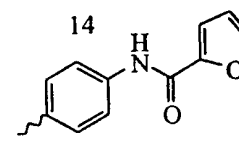
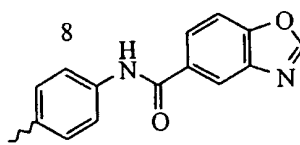
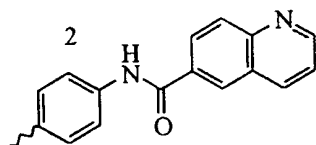
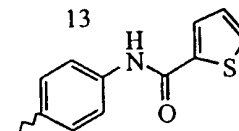
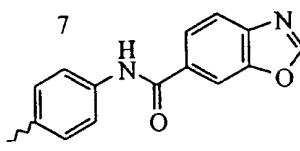
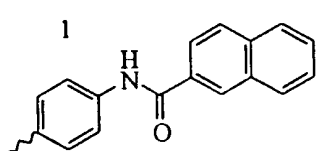
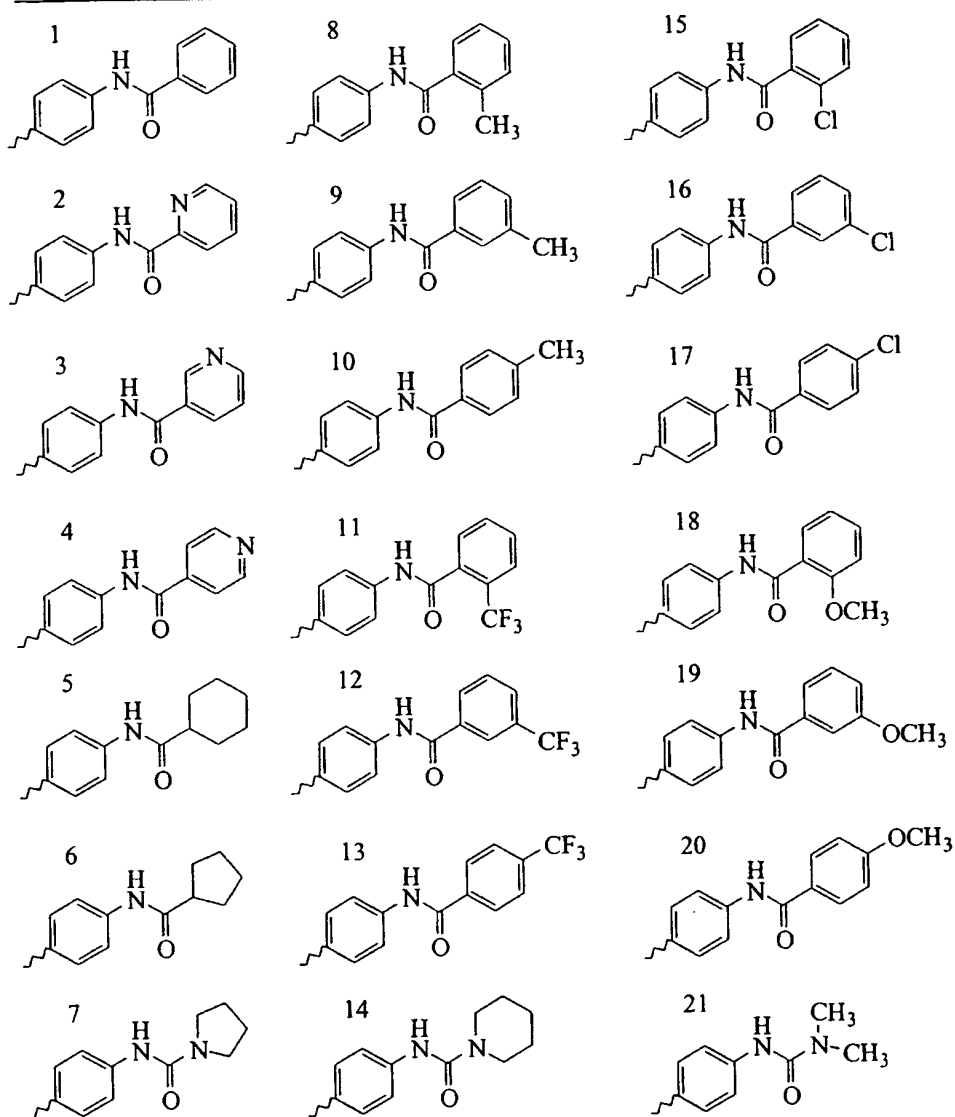
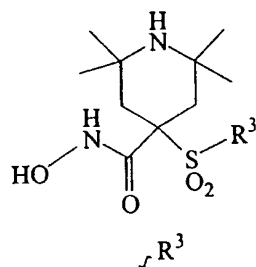
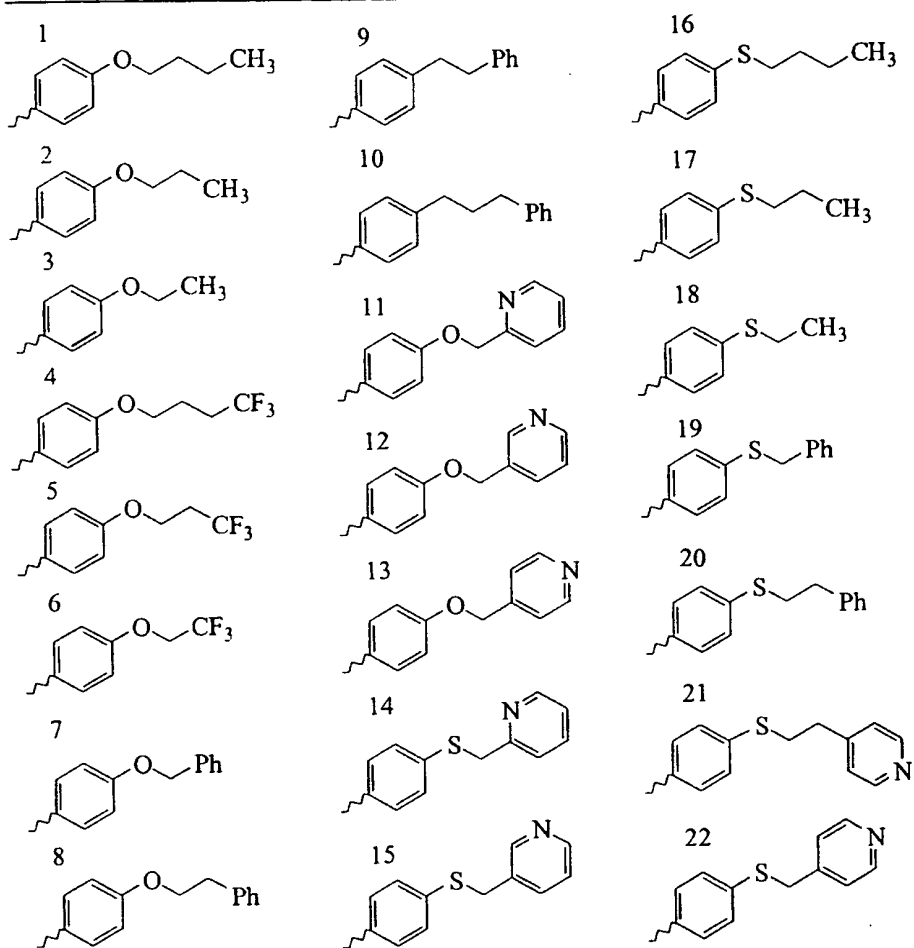
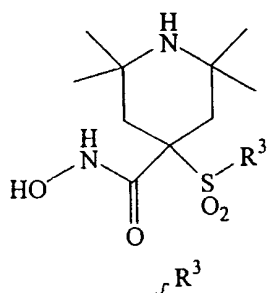
 R^3 

Table 25



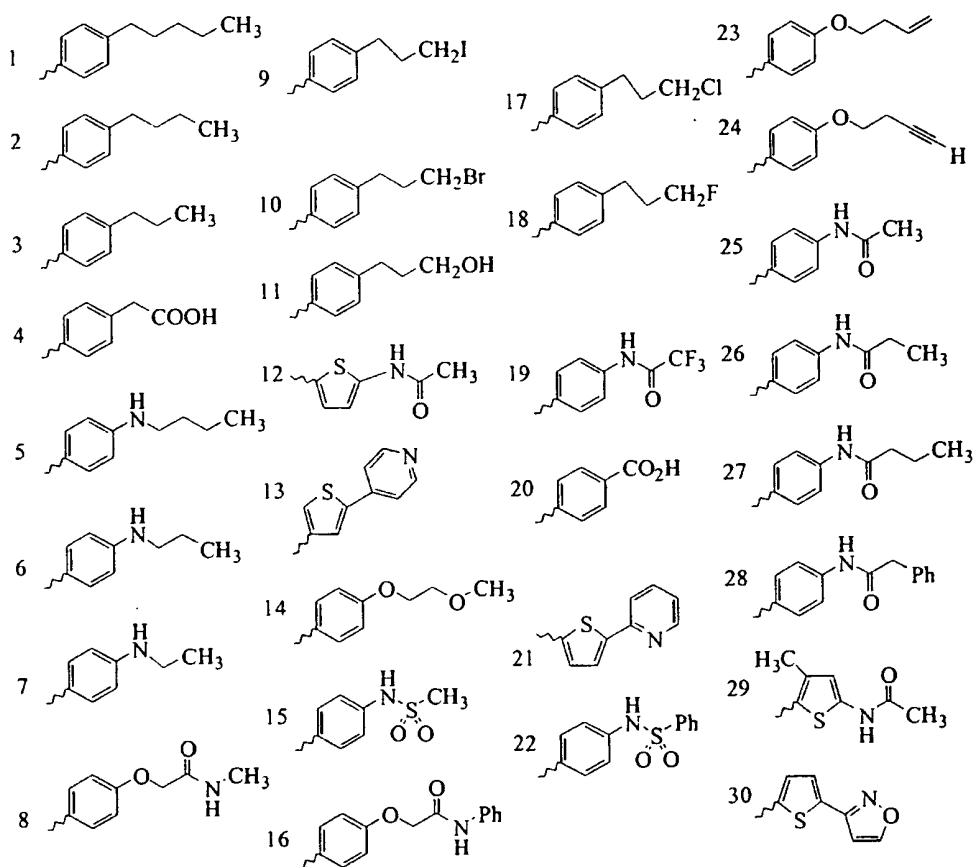
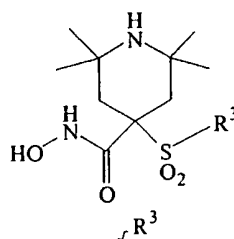
- 155 -

Table 26



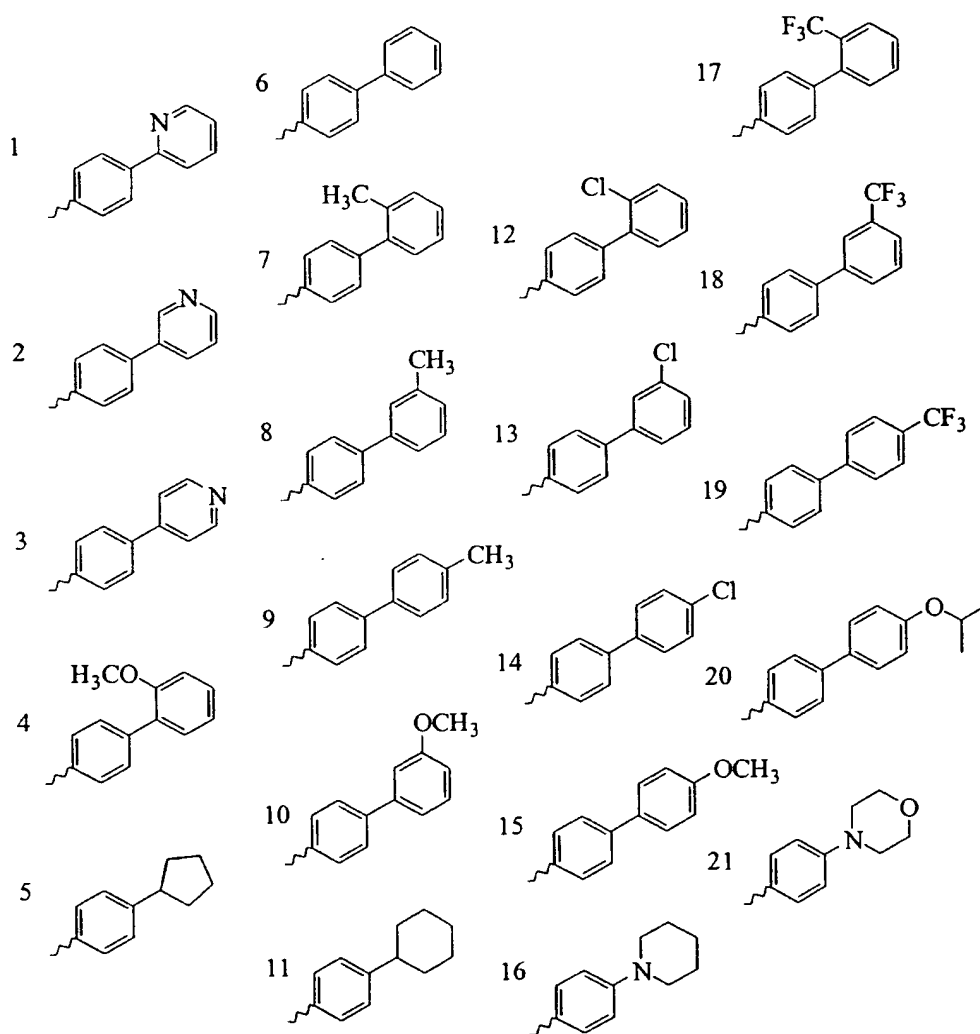
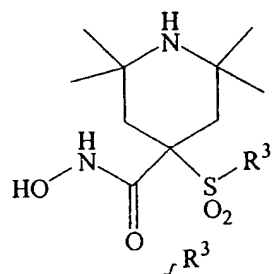
-156-

Table 27



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Table 28



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Table 29

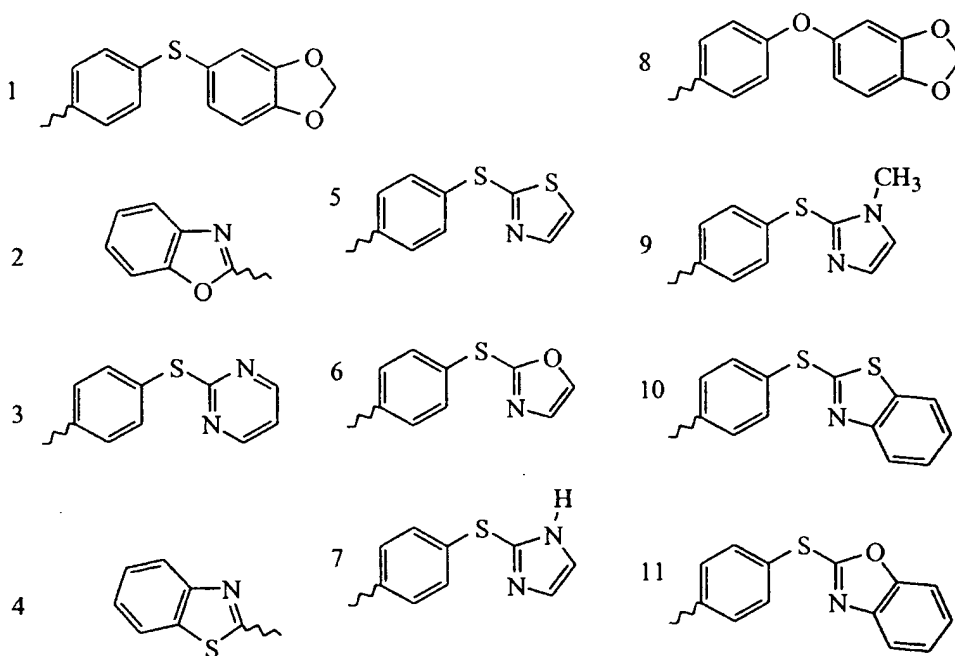
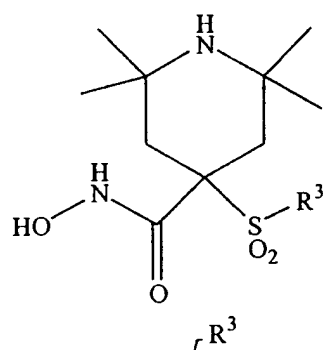
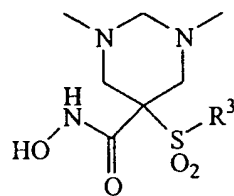
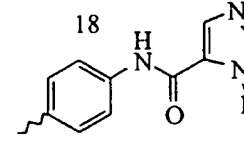
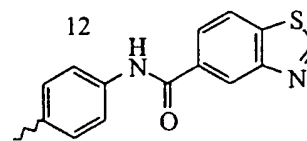
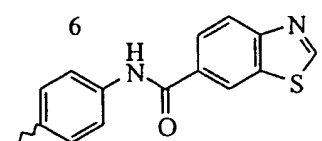
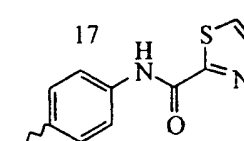
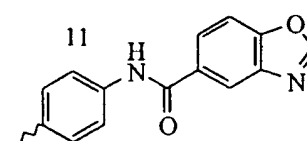
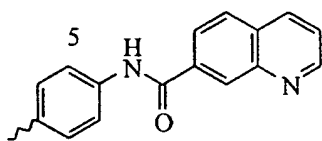
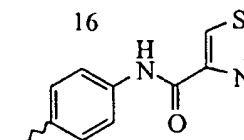
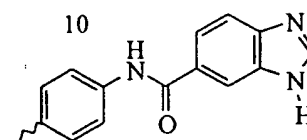
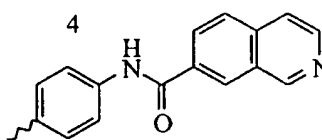
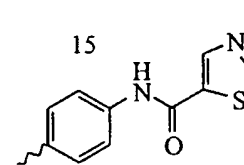
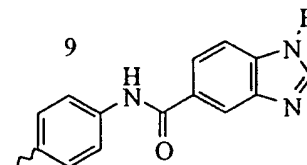
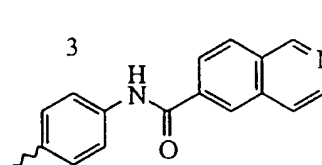
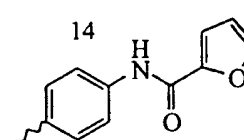
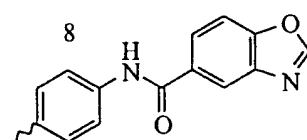
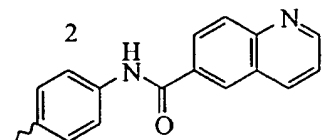
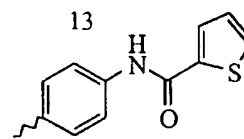
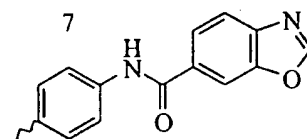
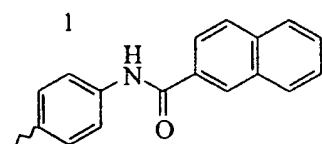


Table 30

 R^3 

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Table 31

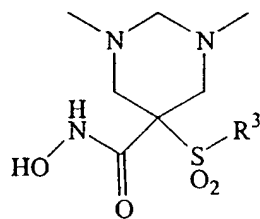
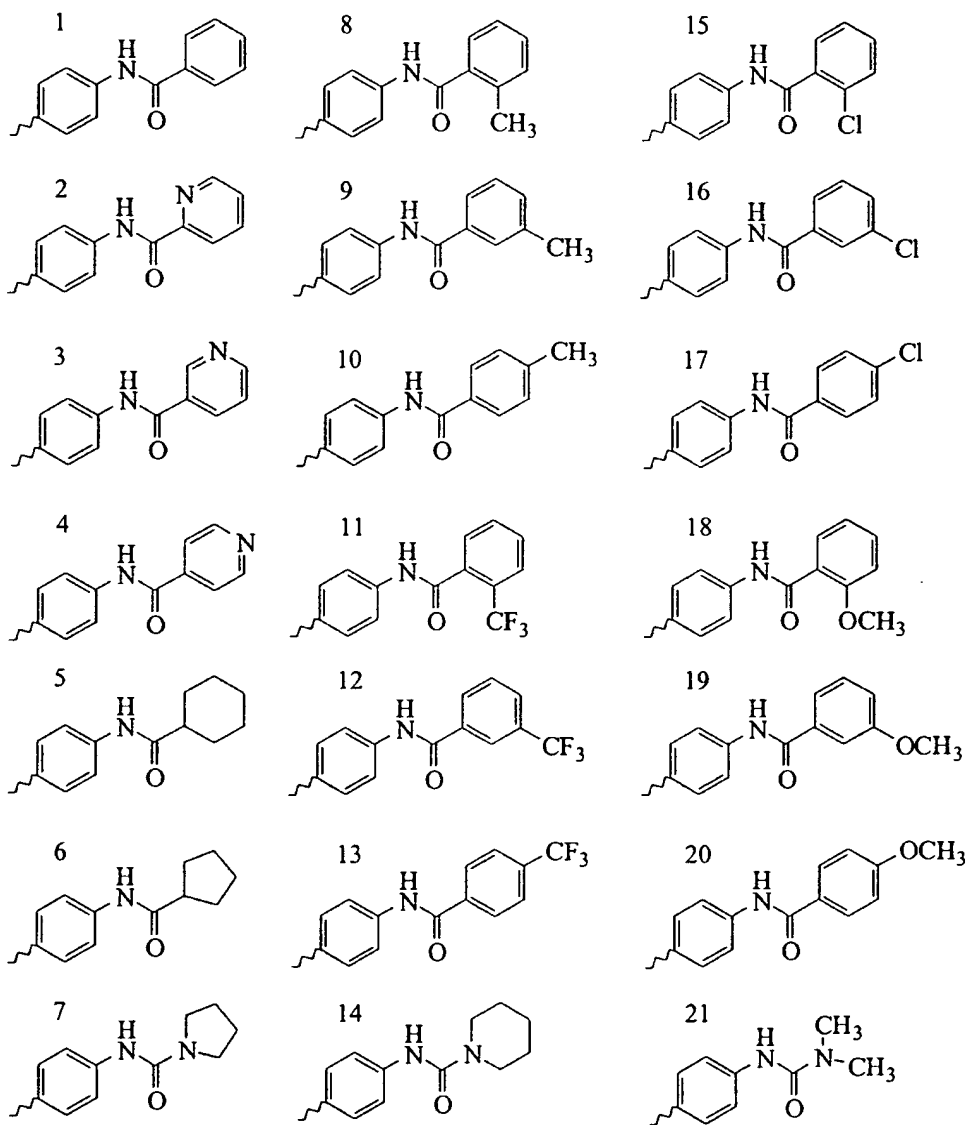
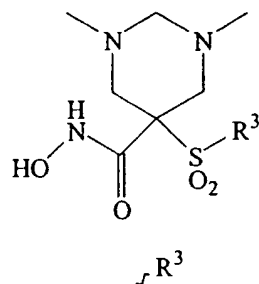
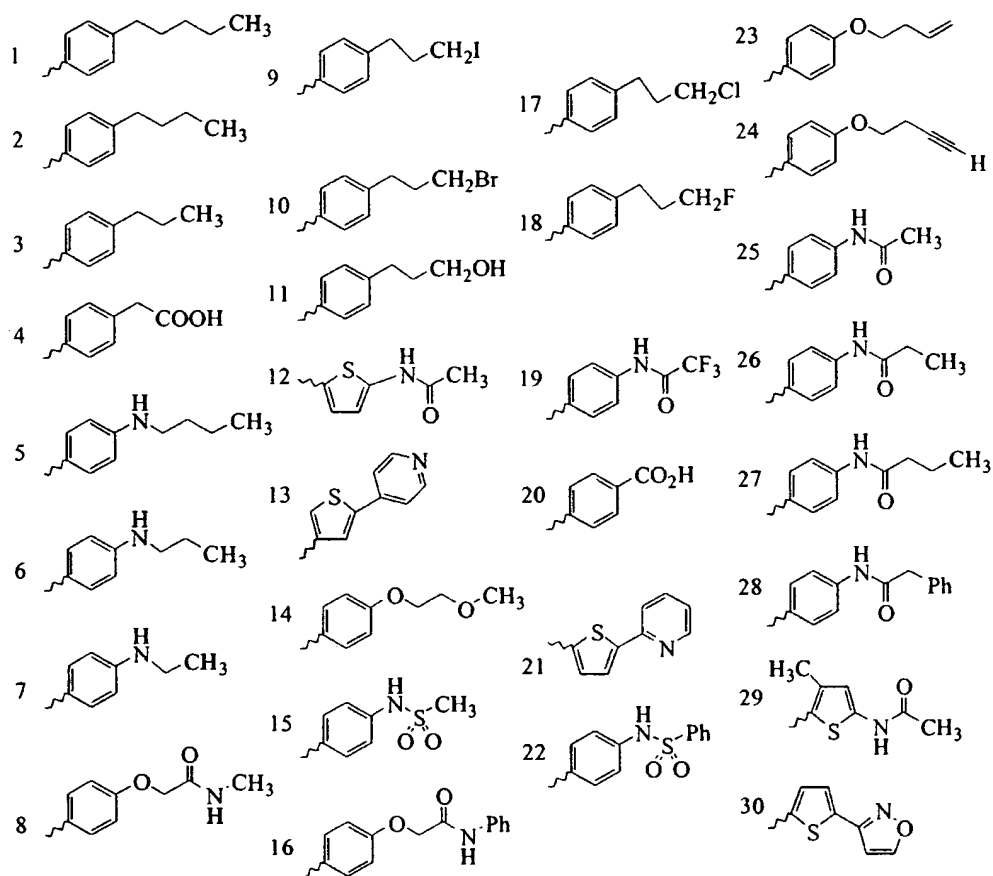
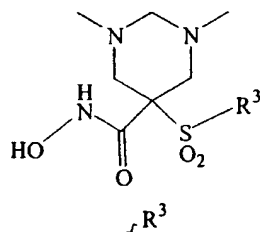
 R^3 

Table 32

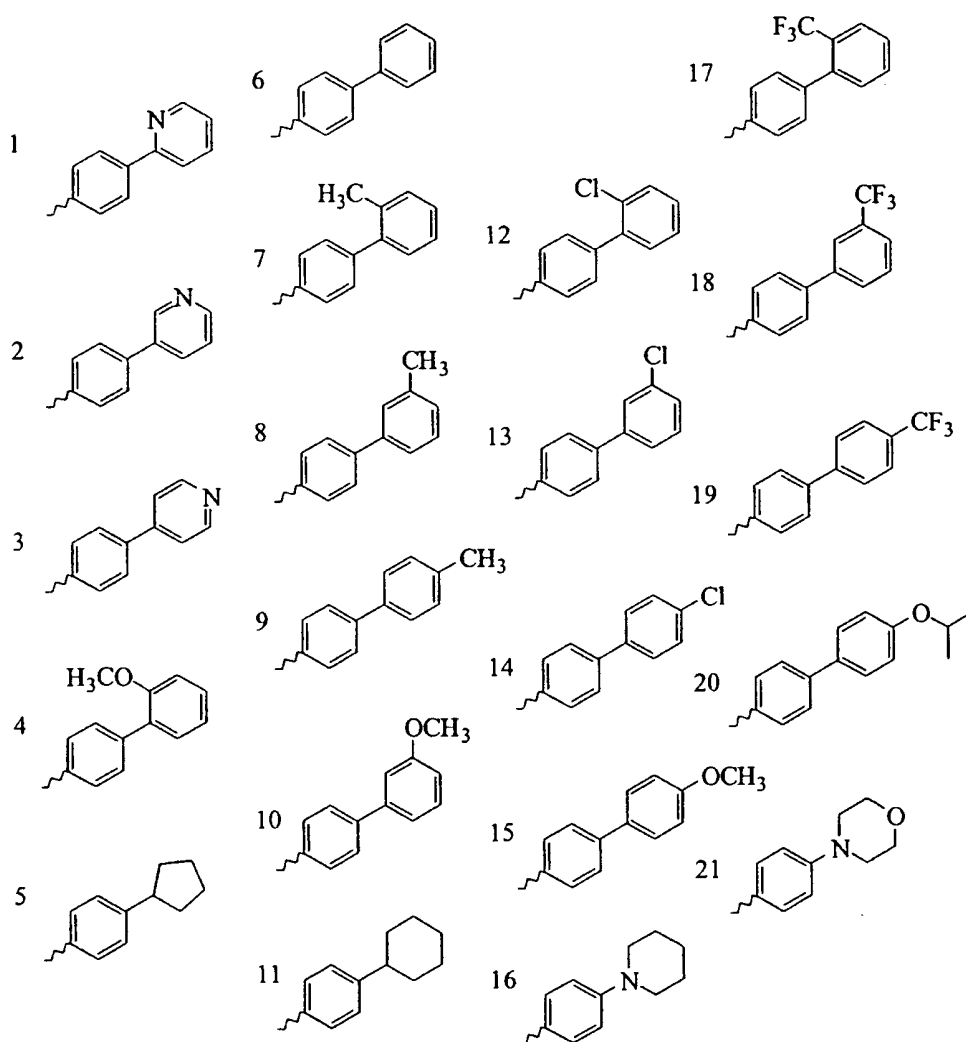
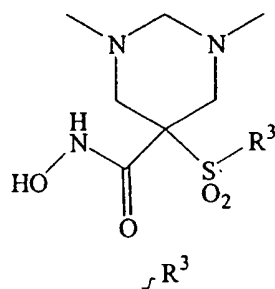


1 	9 	16
2 	10 	17
3 	11 	18
4 	12 	19
5 	13 	20
6 	14 	21
7 	15 	22
8 		

Table 33

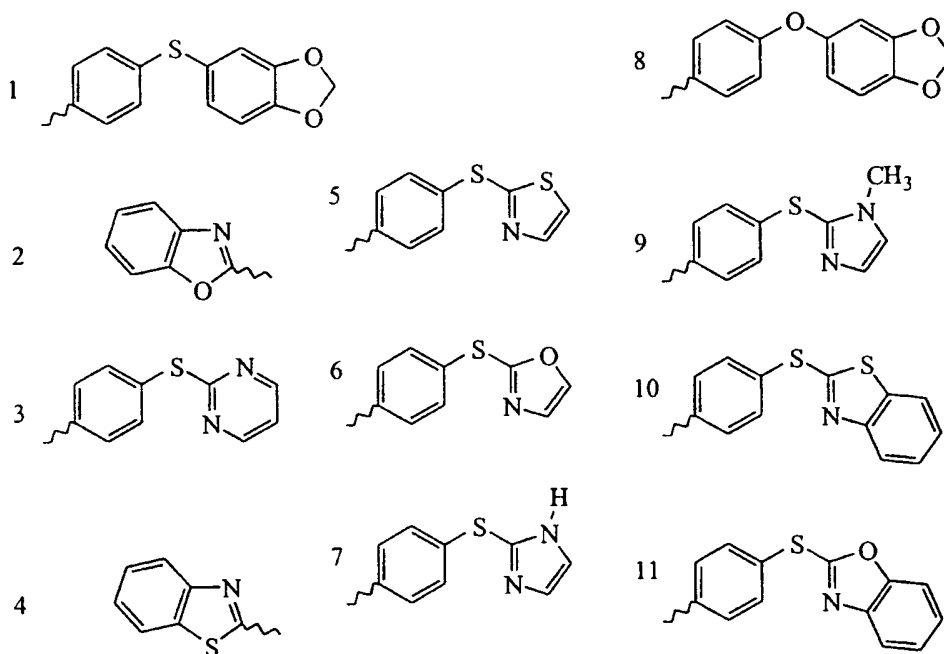
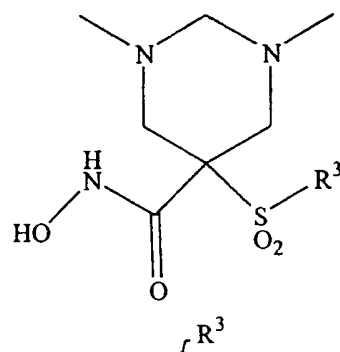
- 163 -

Table 34



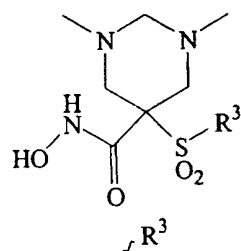
- 164 -

Table 35



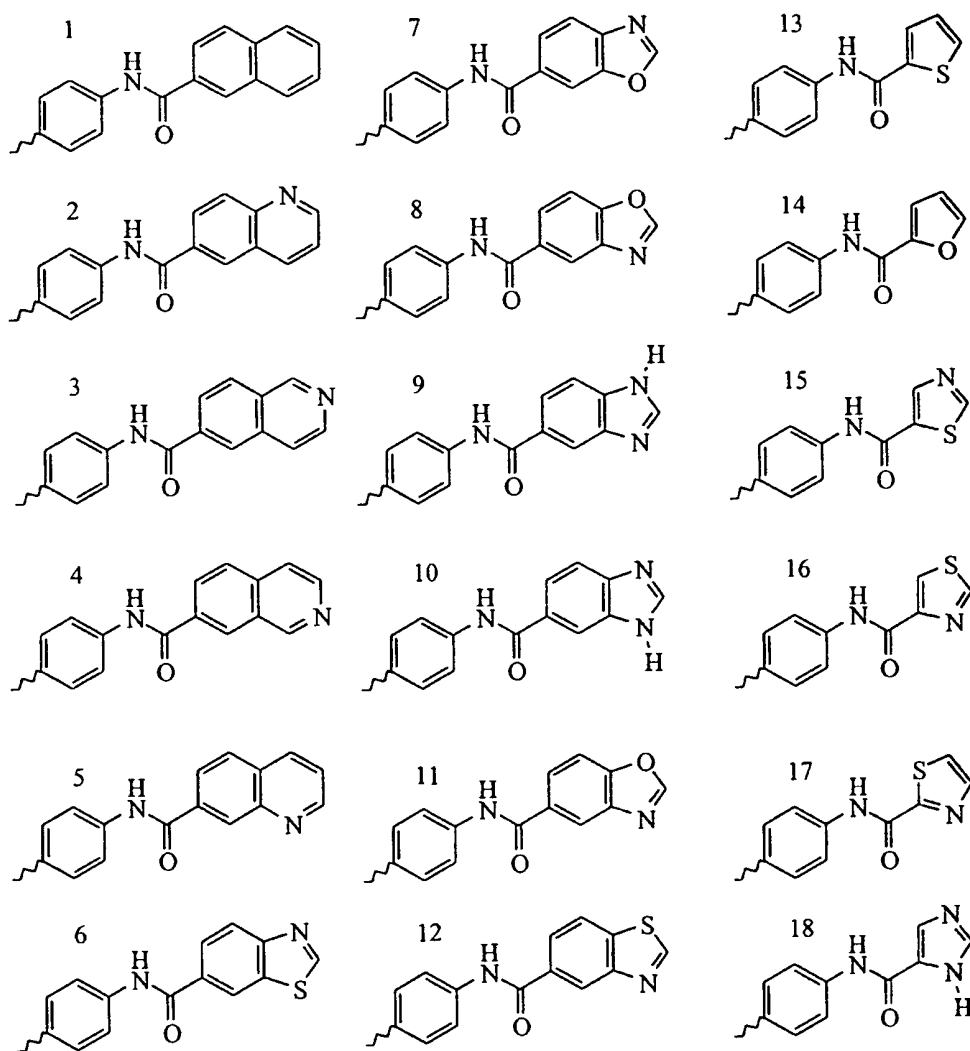
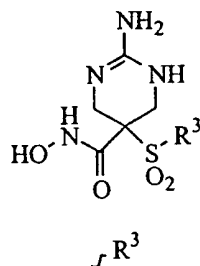
-165-

Table 36



1 	8 	15
2 	9 	16
3 	10 	17
4 	11 	18
5 	12 	19
6 	13 	20
7 	14 	21

Table 37



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Table 38

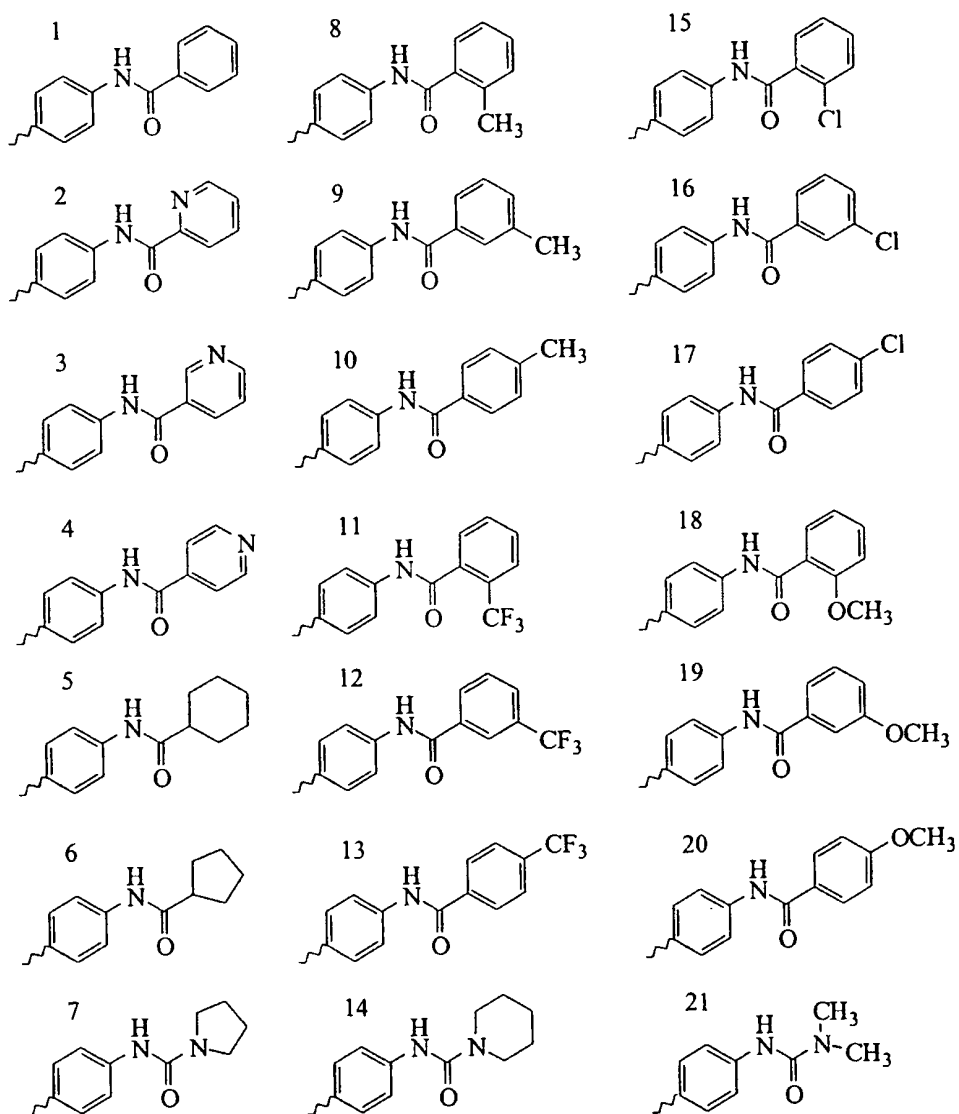
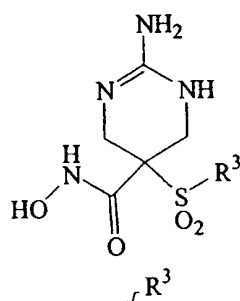
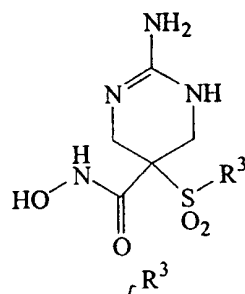
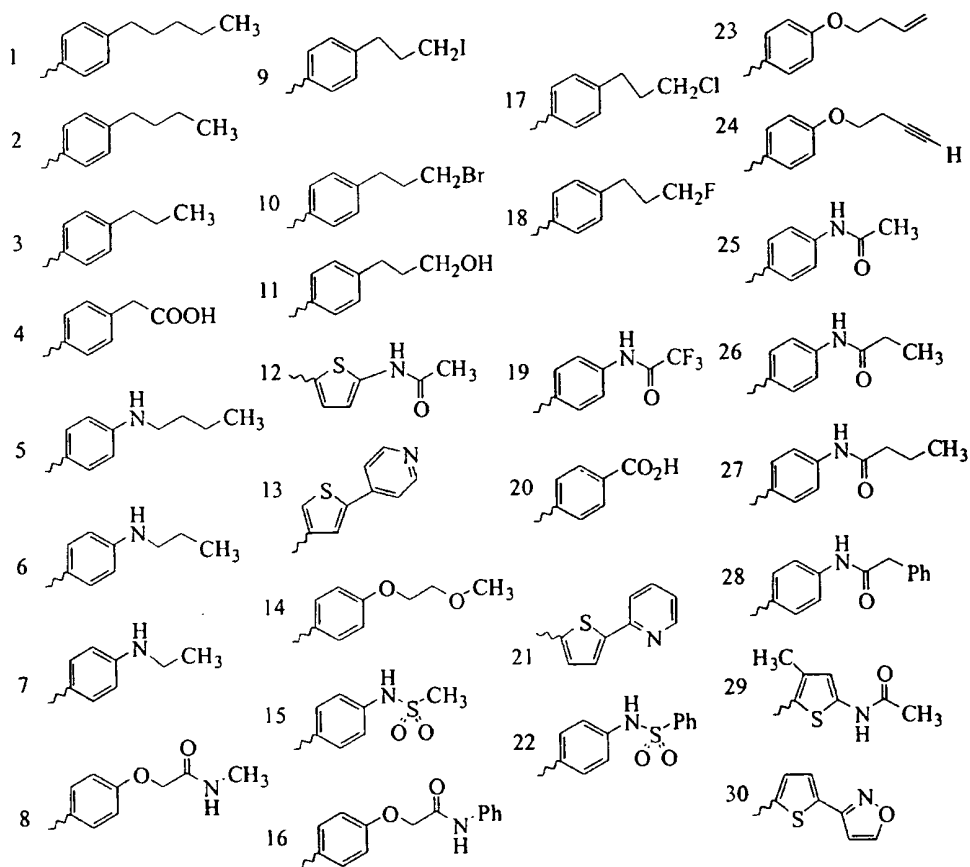
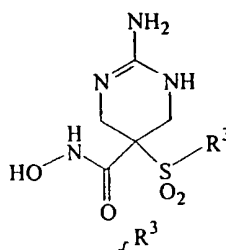


Table 39



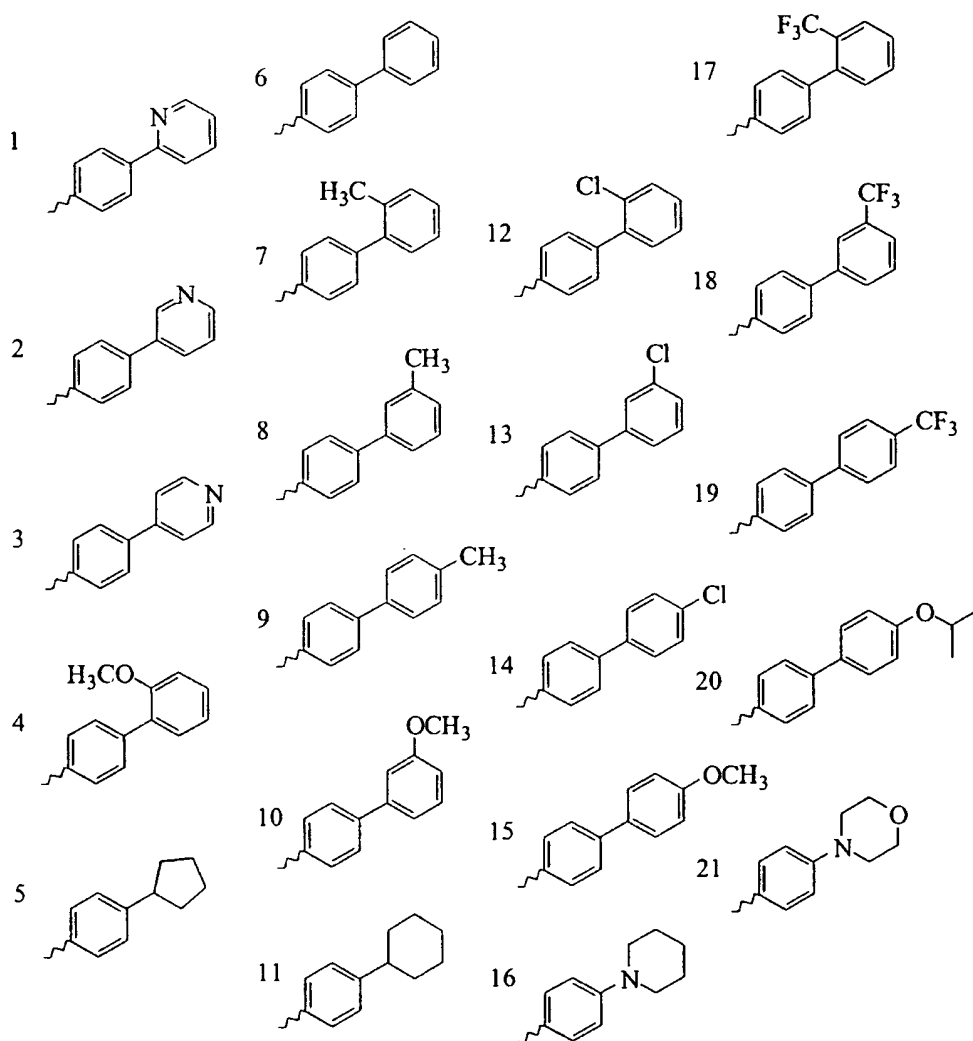
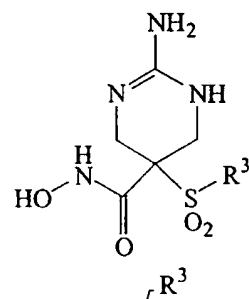
1 	9 	16
2 	10 	17
3 	11 	18
4 	12 	19
5 	13 	20
6 	14 	21
7 	15 	22
8 		

Table 40



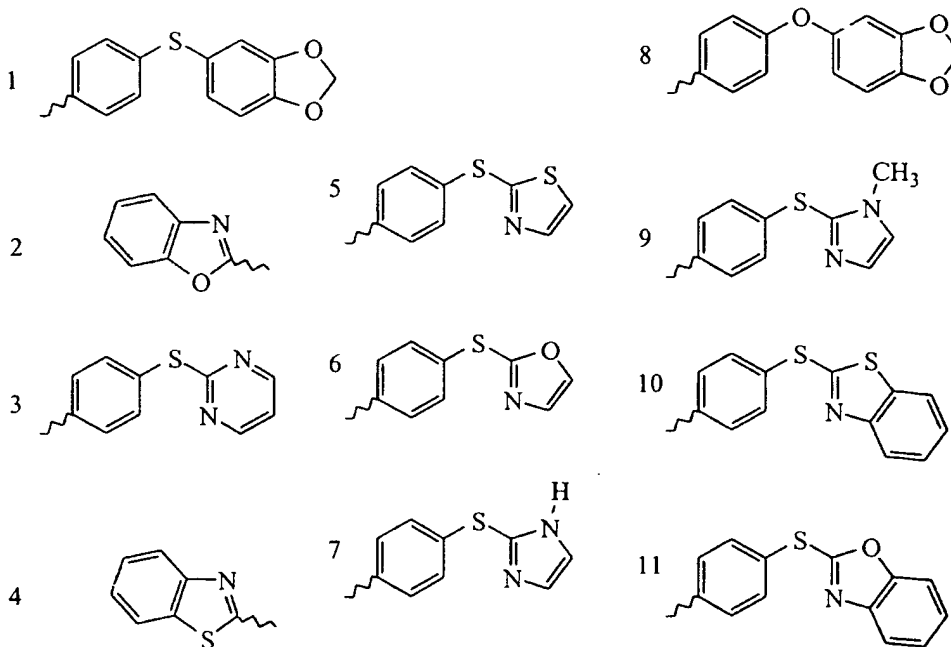
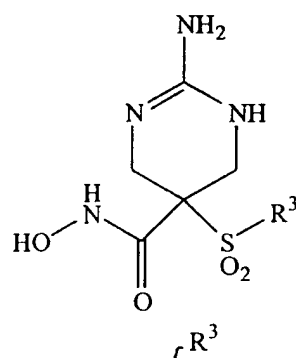
-170-

Table 41



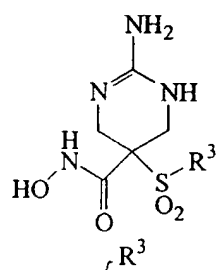
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Table 42



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Table 43



1 	8 	15
2 	9 	16
3 	10 	17
4 	11 	18
5 	12 	19
6 	13 	20
7 	14 	21

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Table 44

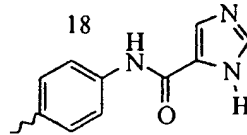
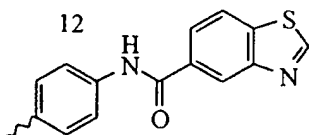
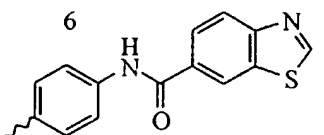
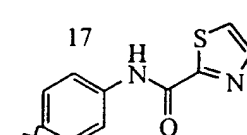
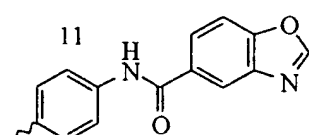
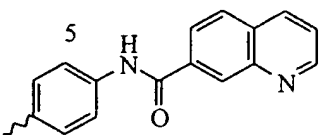
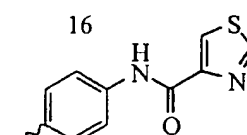
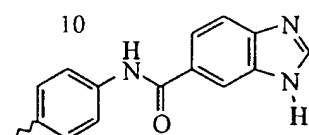
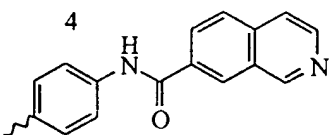
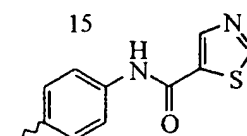
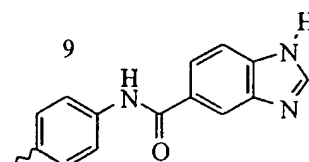
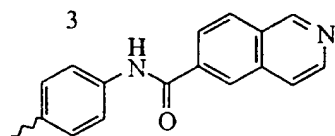
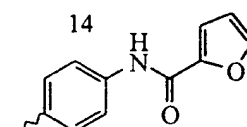
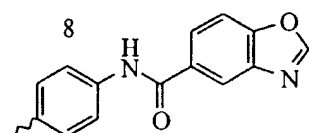
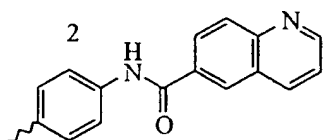
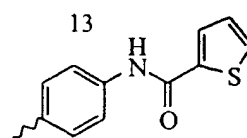
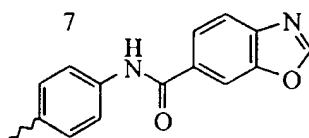
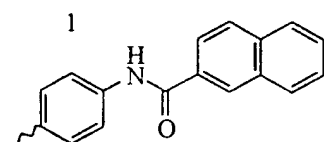
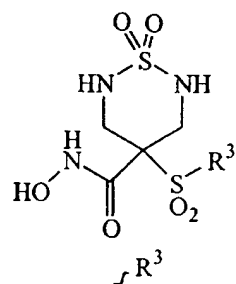
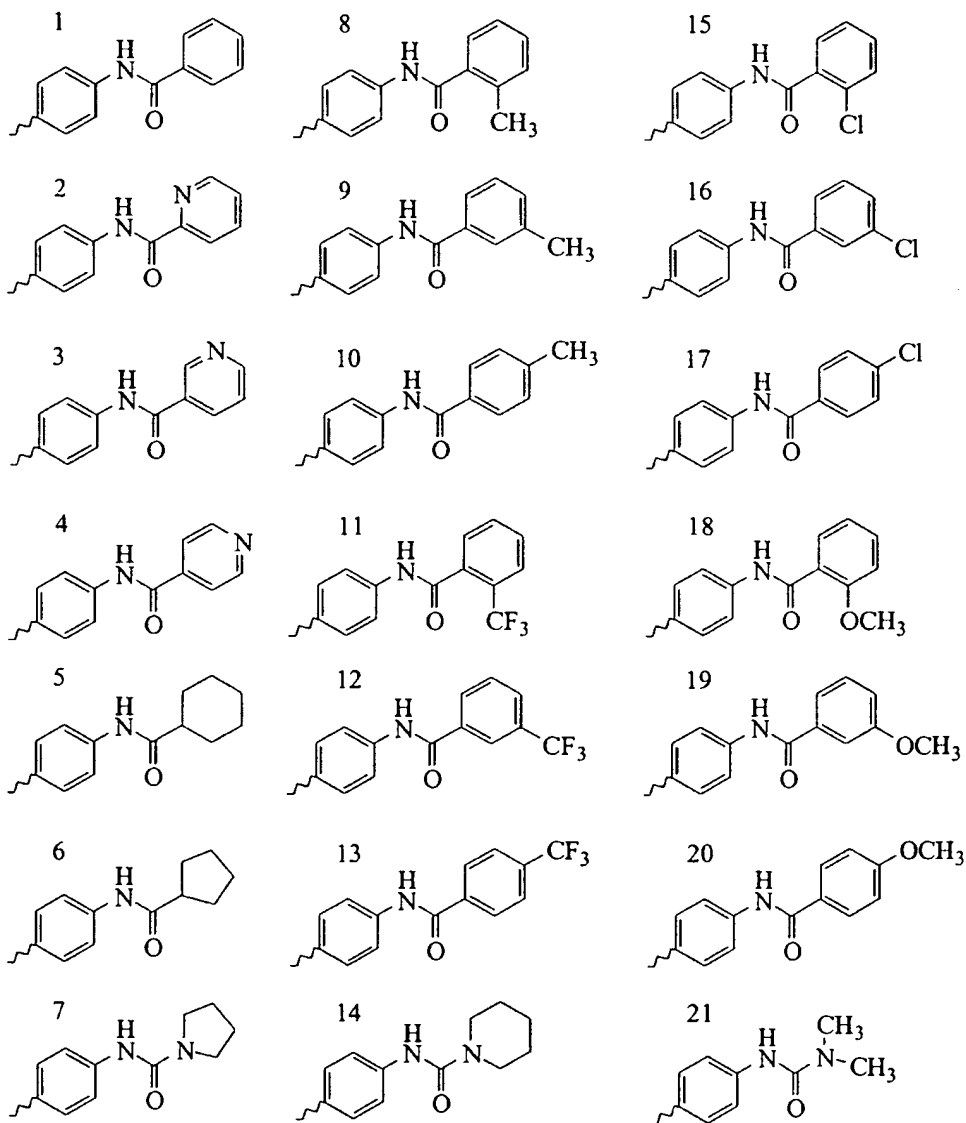
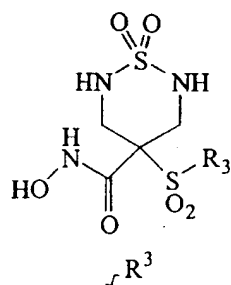


Table 45



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Table 46

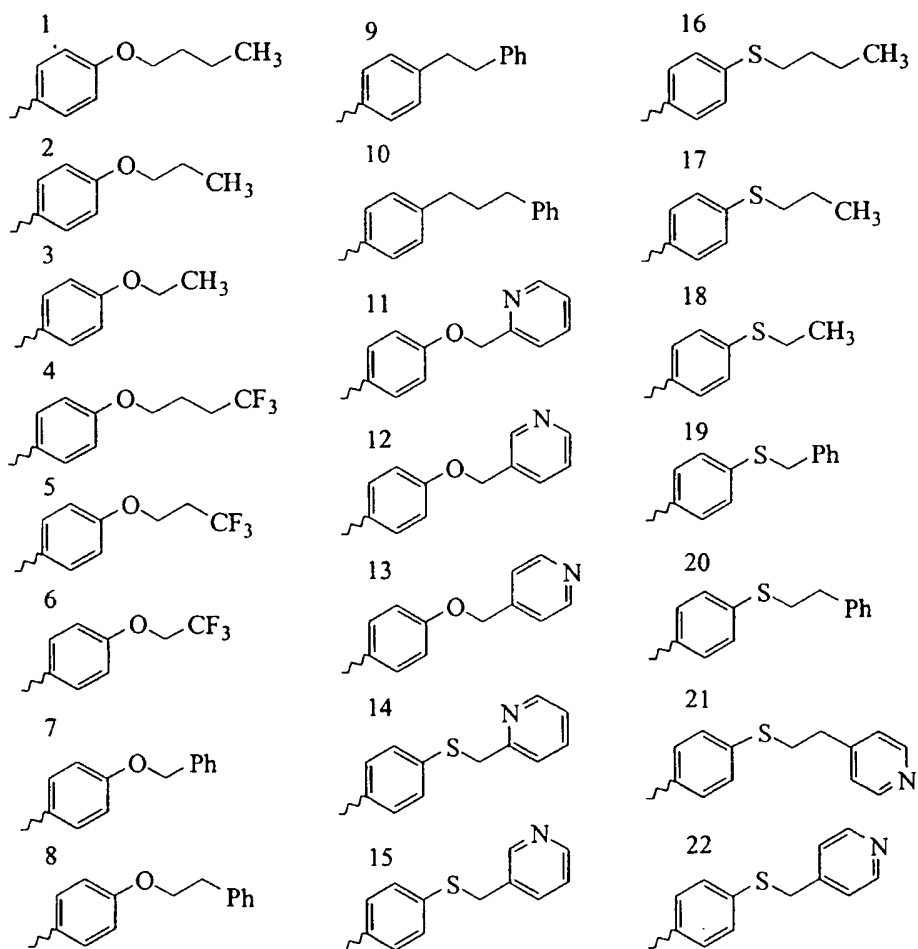
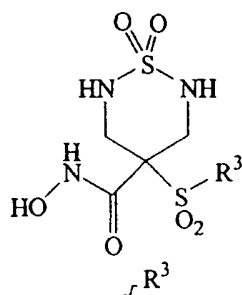
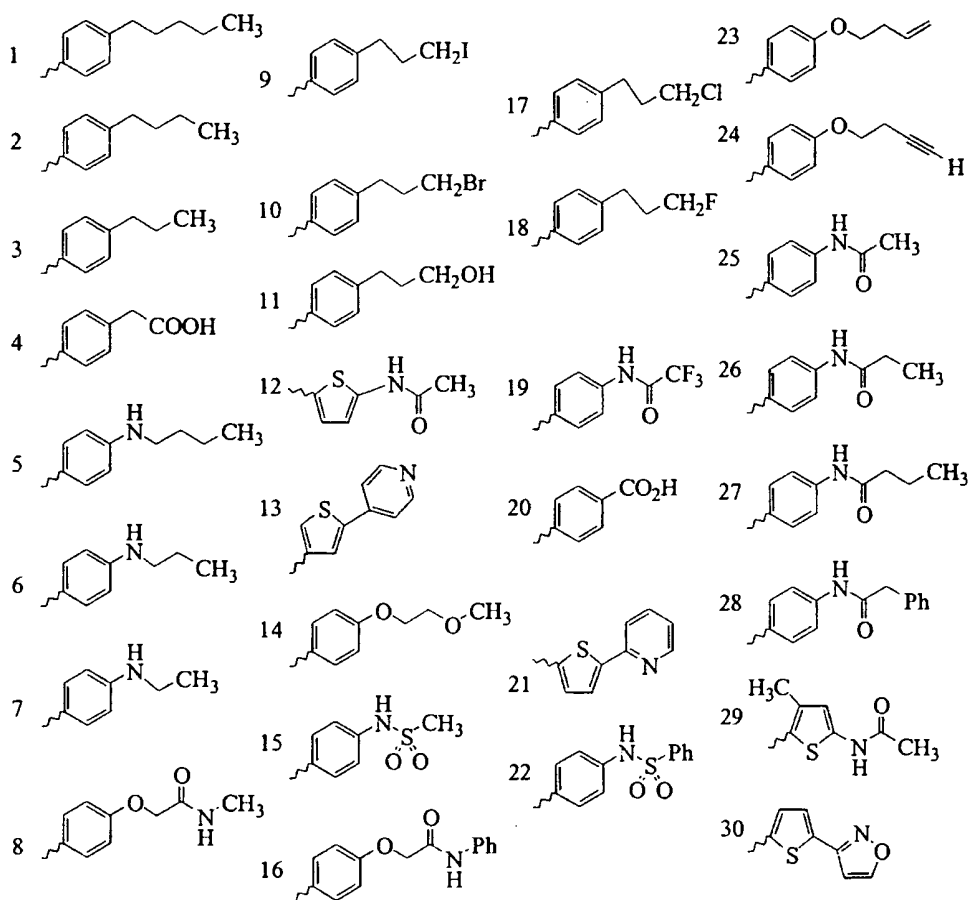
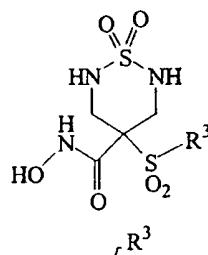
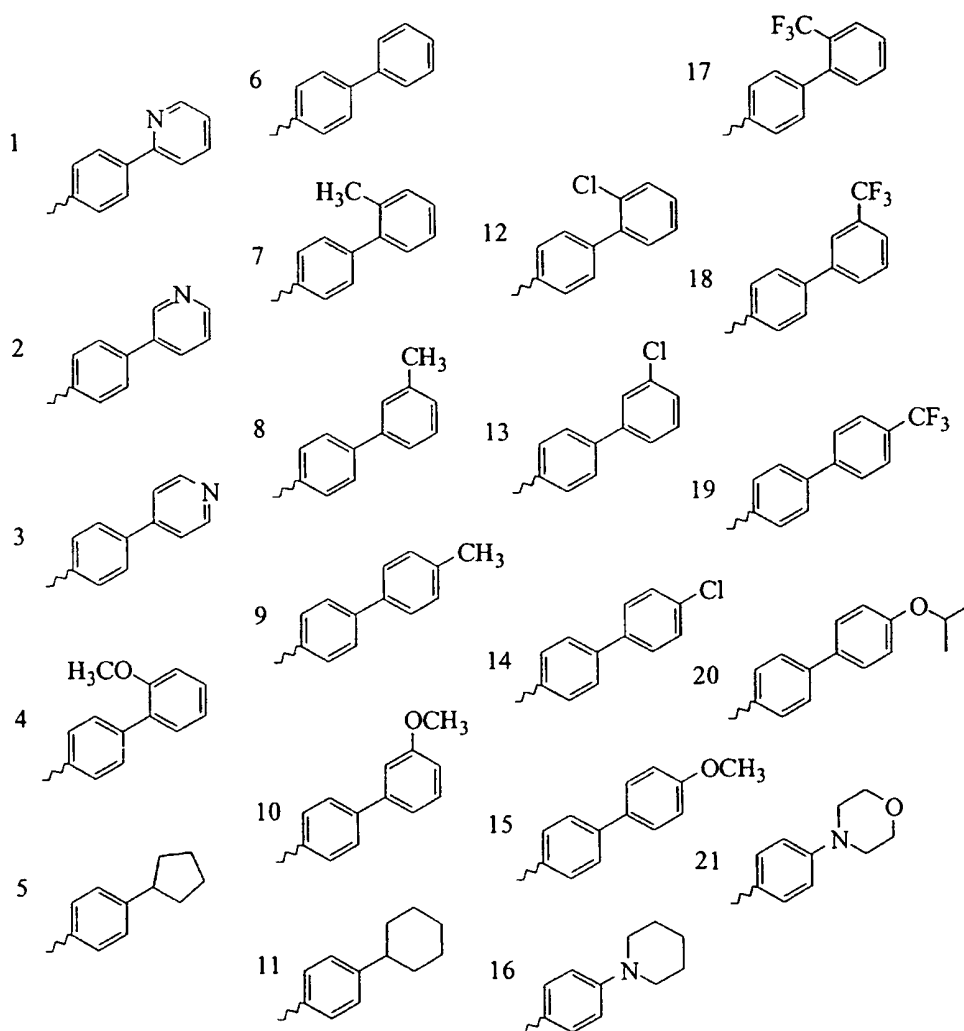
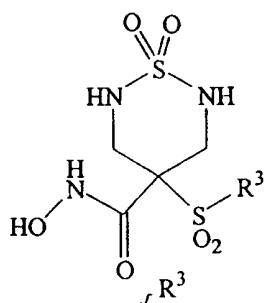


Table 47

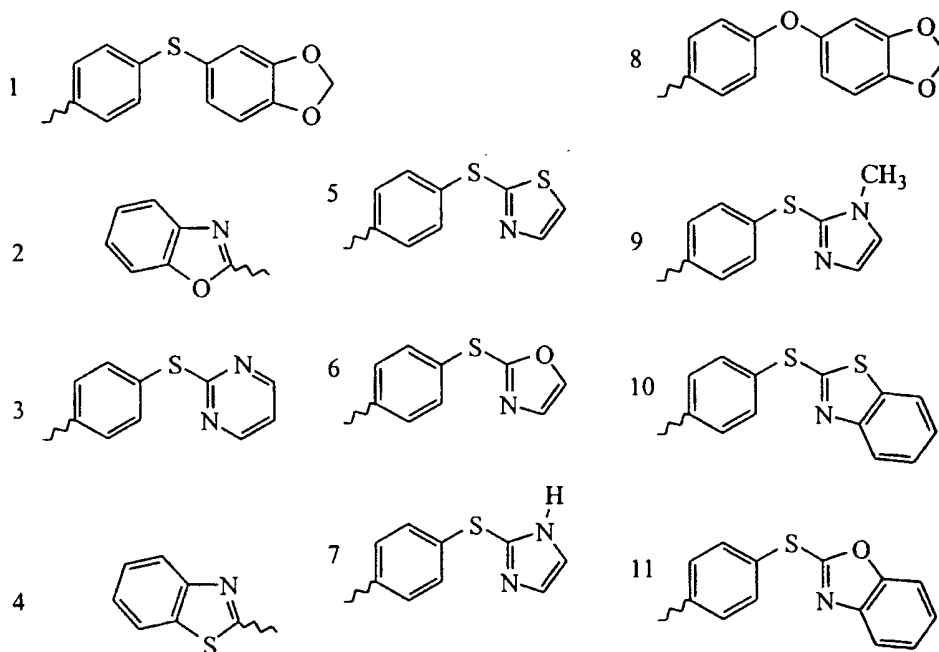
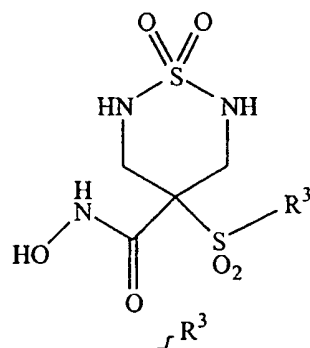
-177-

Table 48



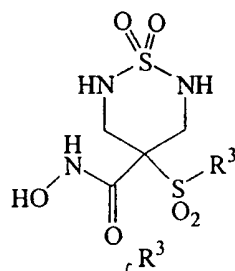
- 178 -

Table 49



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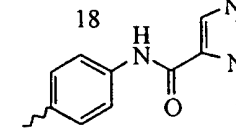
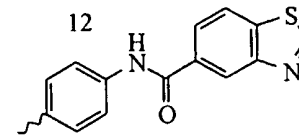
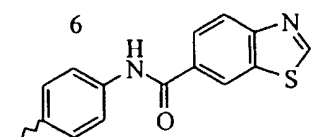
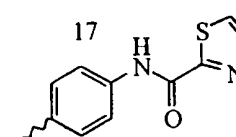
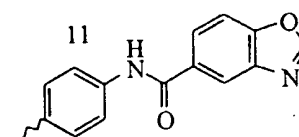
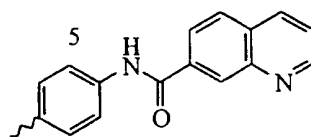
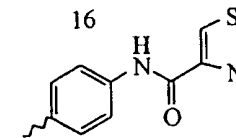
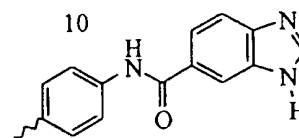
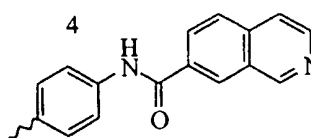
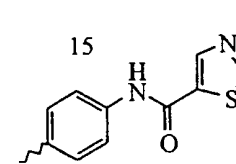
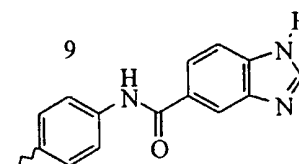
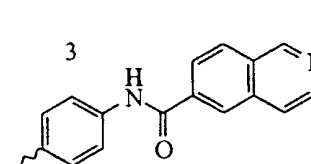
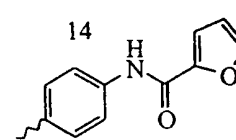
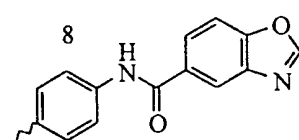
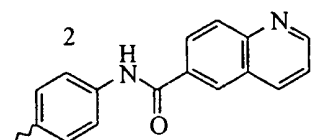
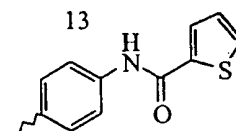
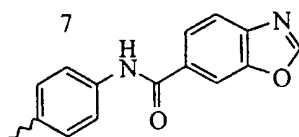
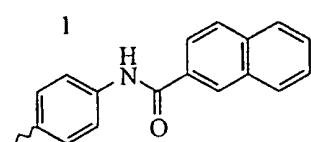
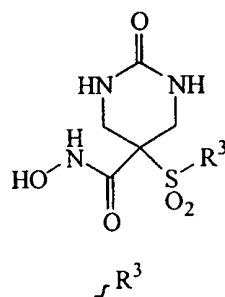
Table 50



1	8	15
2	9	16
3	10	17
4	11	18
5	12	19
6	13	20
7	14	21

-180-

Table 51



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Table 52

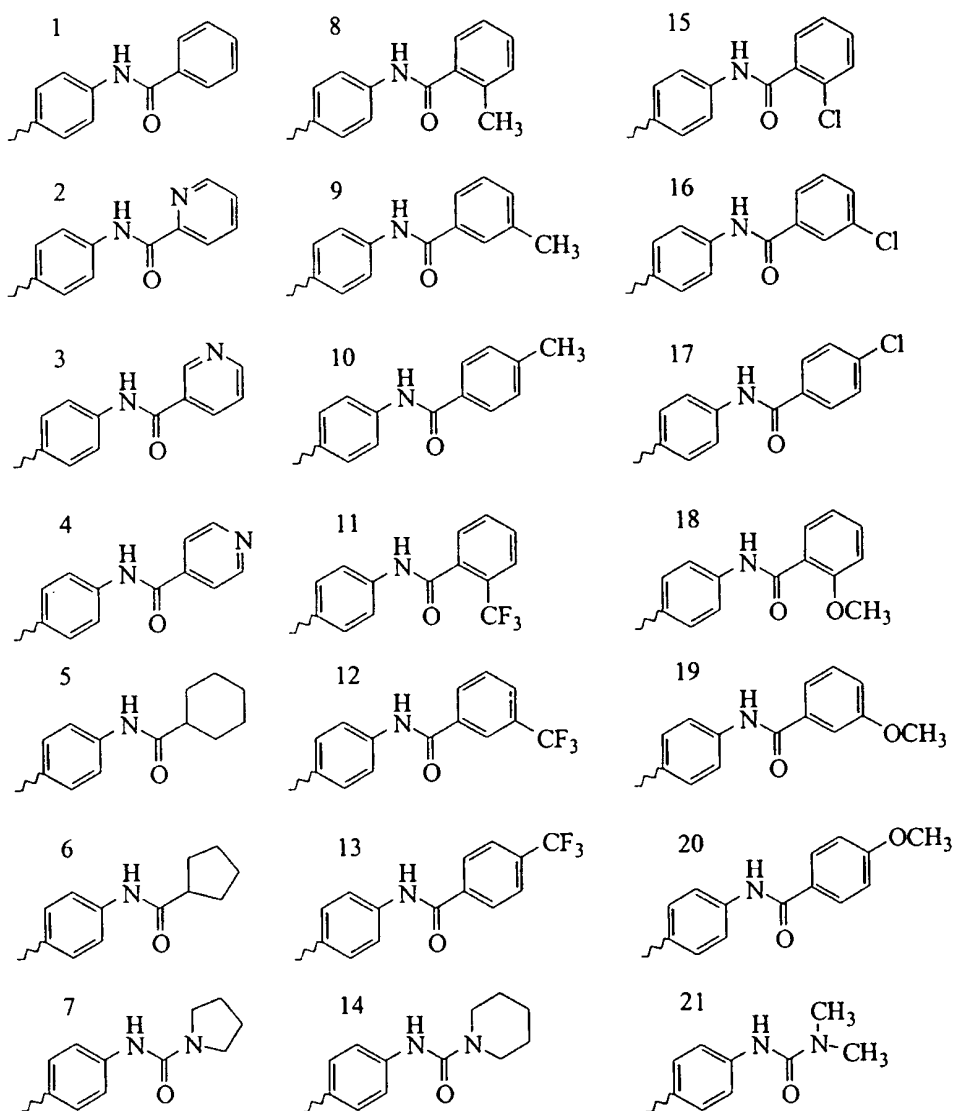
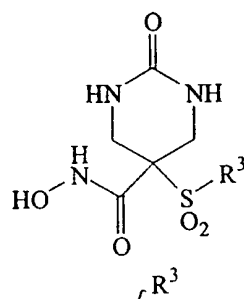
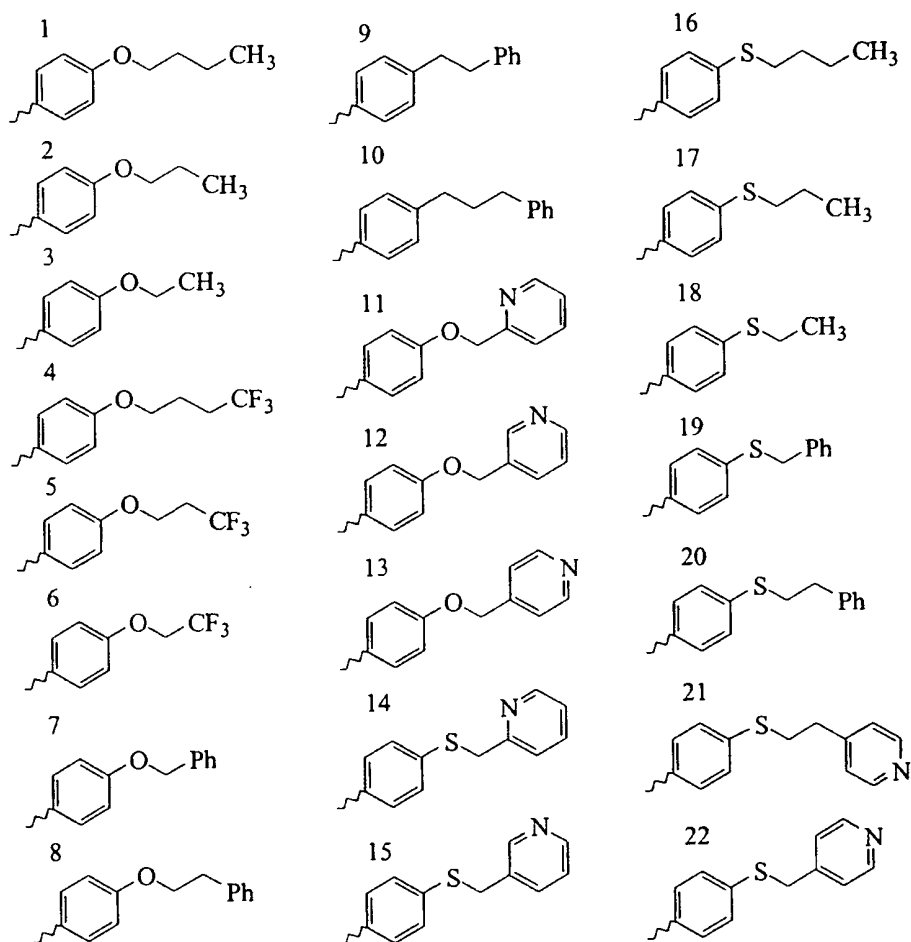
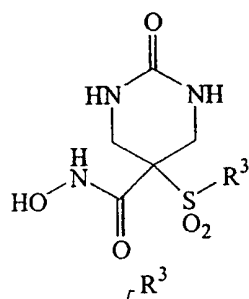
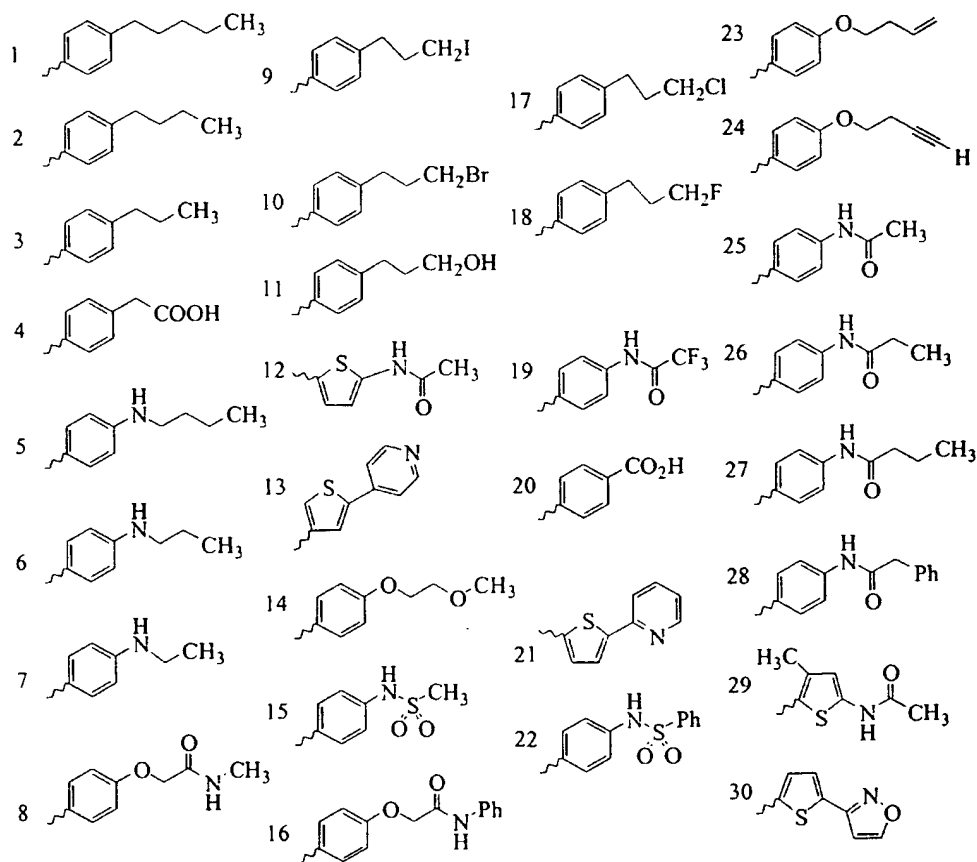
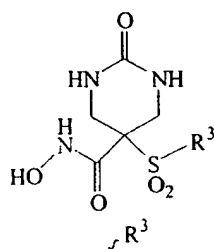


Table 53



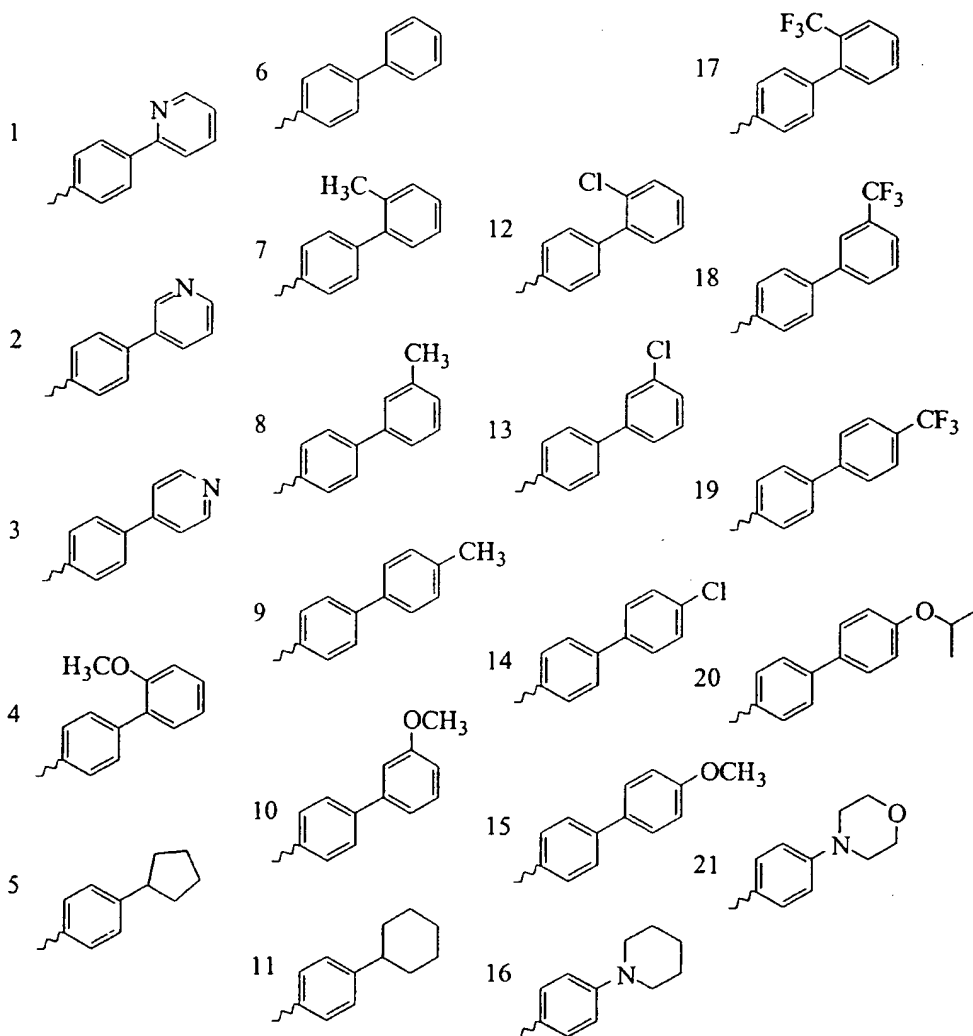
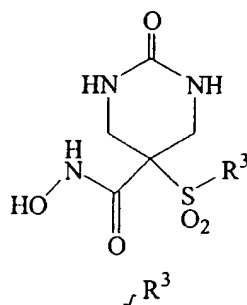
-183-

Table 54



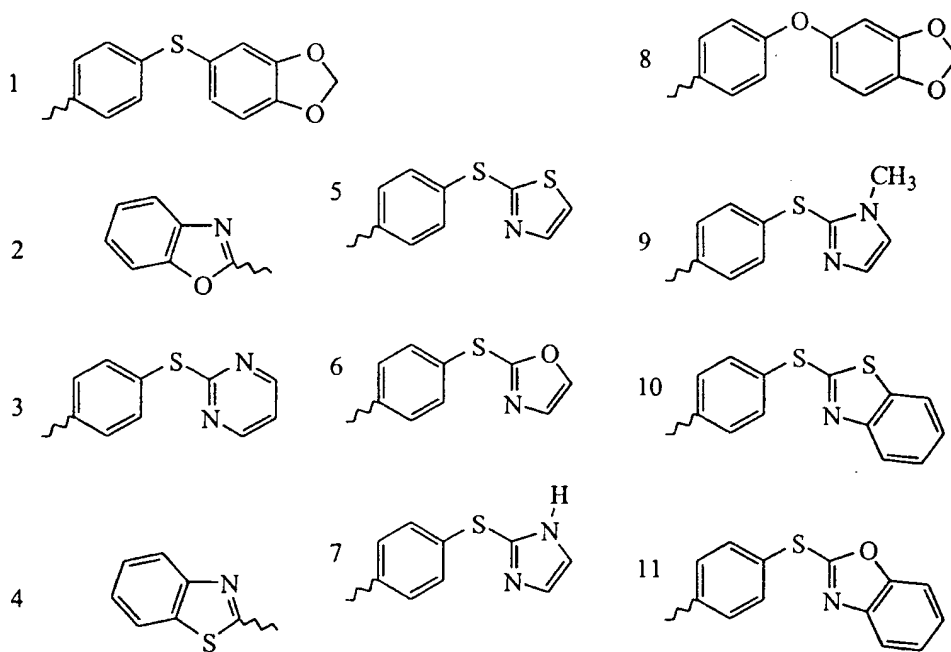
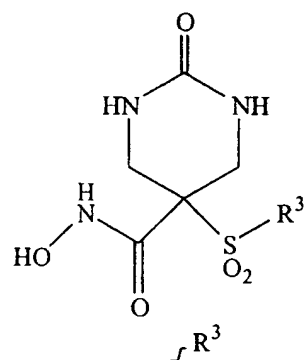
-184-

Table 55



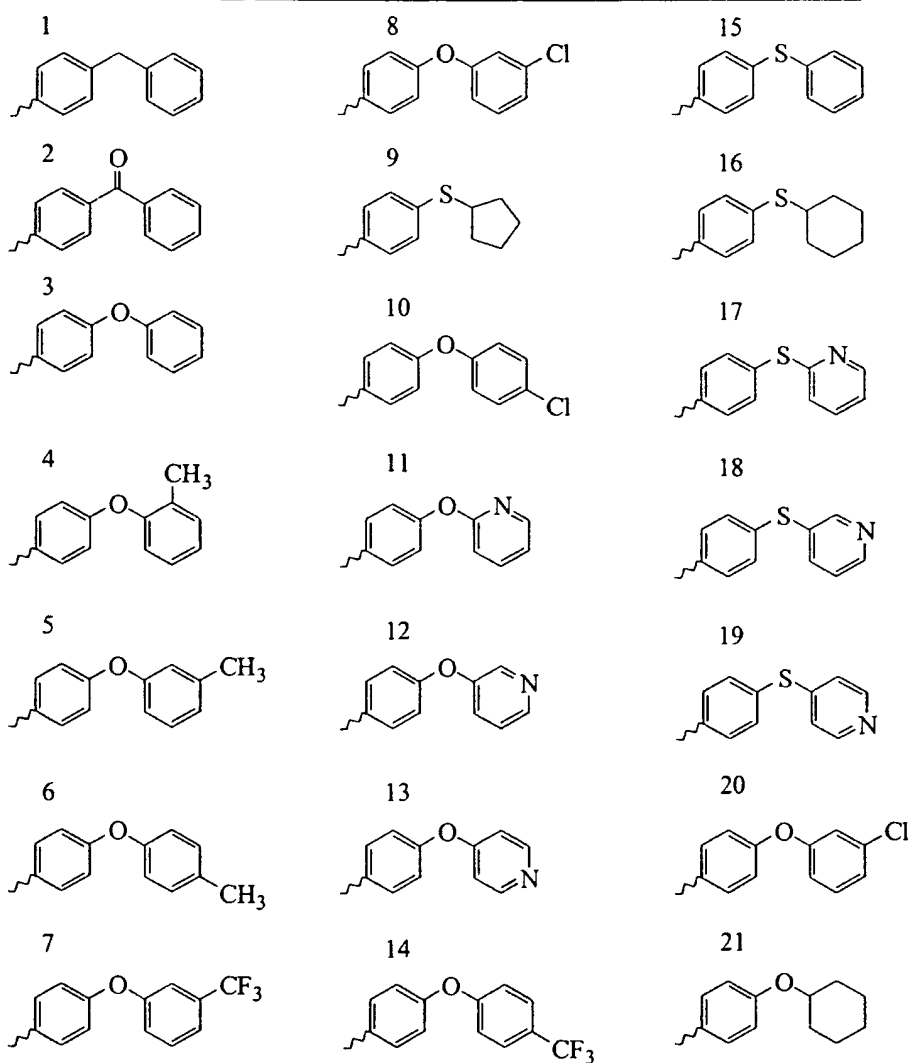
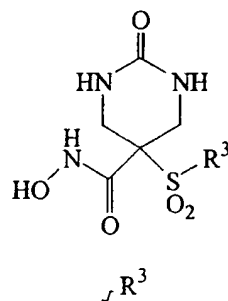
- 185 -

Table 56



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Table 57



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Table 58

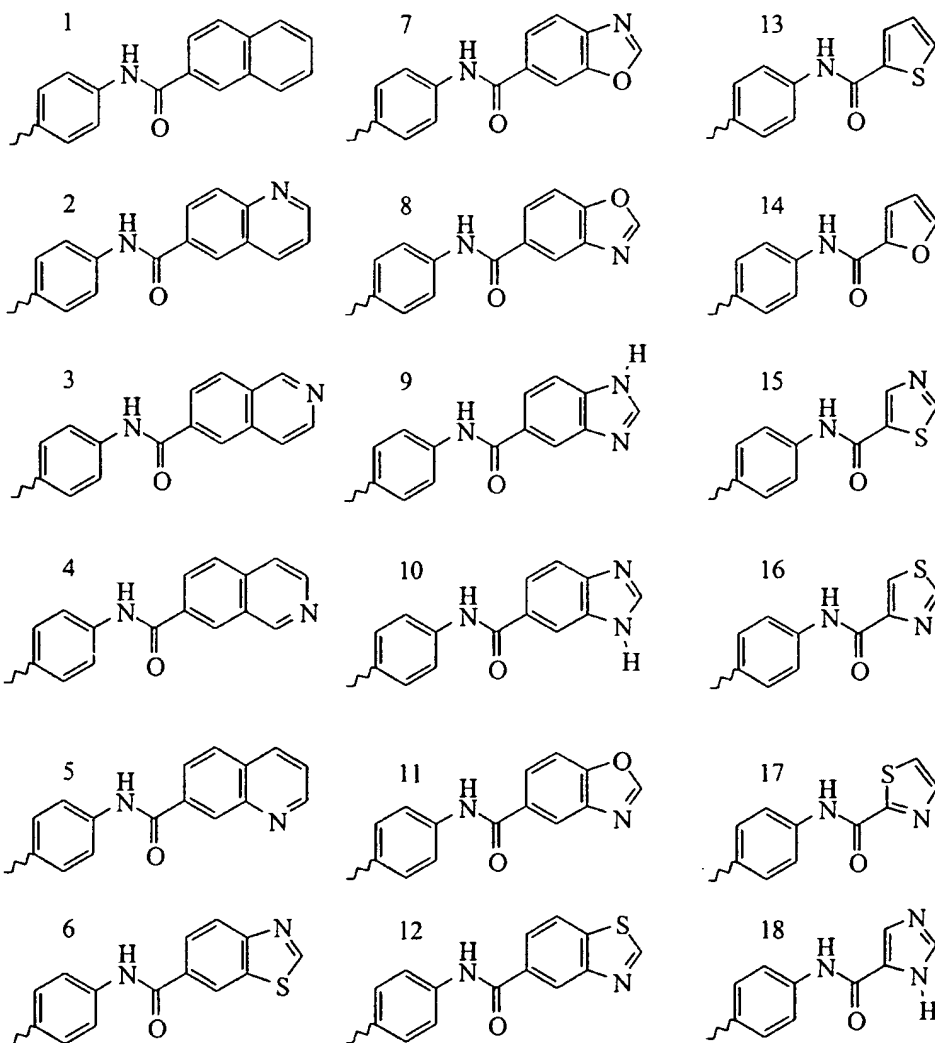
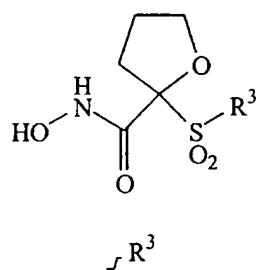
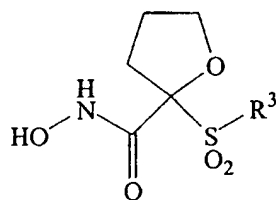
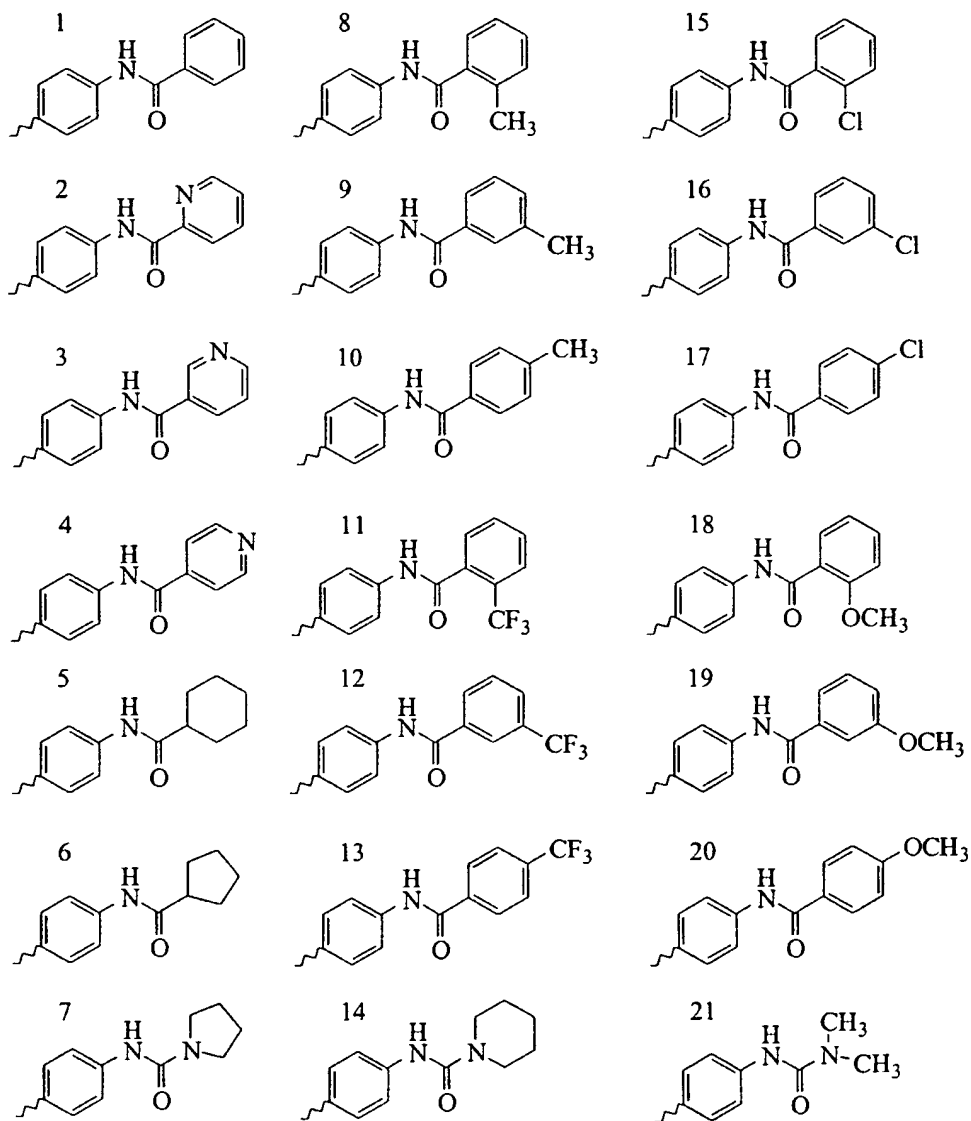
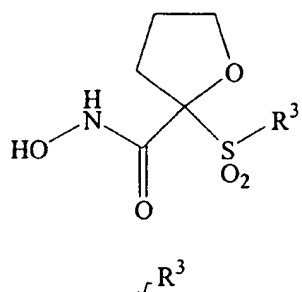


Table 59

 R^3 

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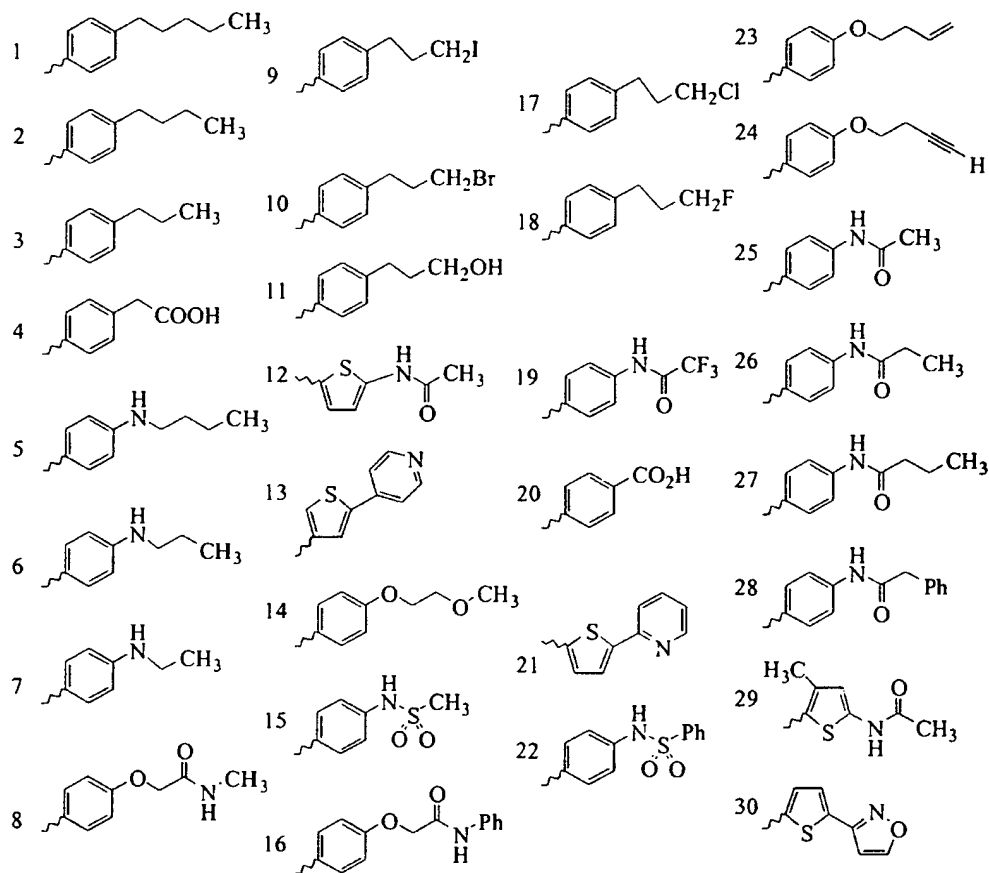
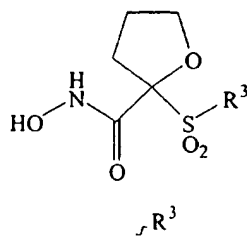
Table 60



1 	9 	16
2 	10 	17
3 	11 	18
4 	12 	19
5 	13 	20
6 	14 	21
7 	15 	22
8 		

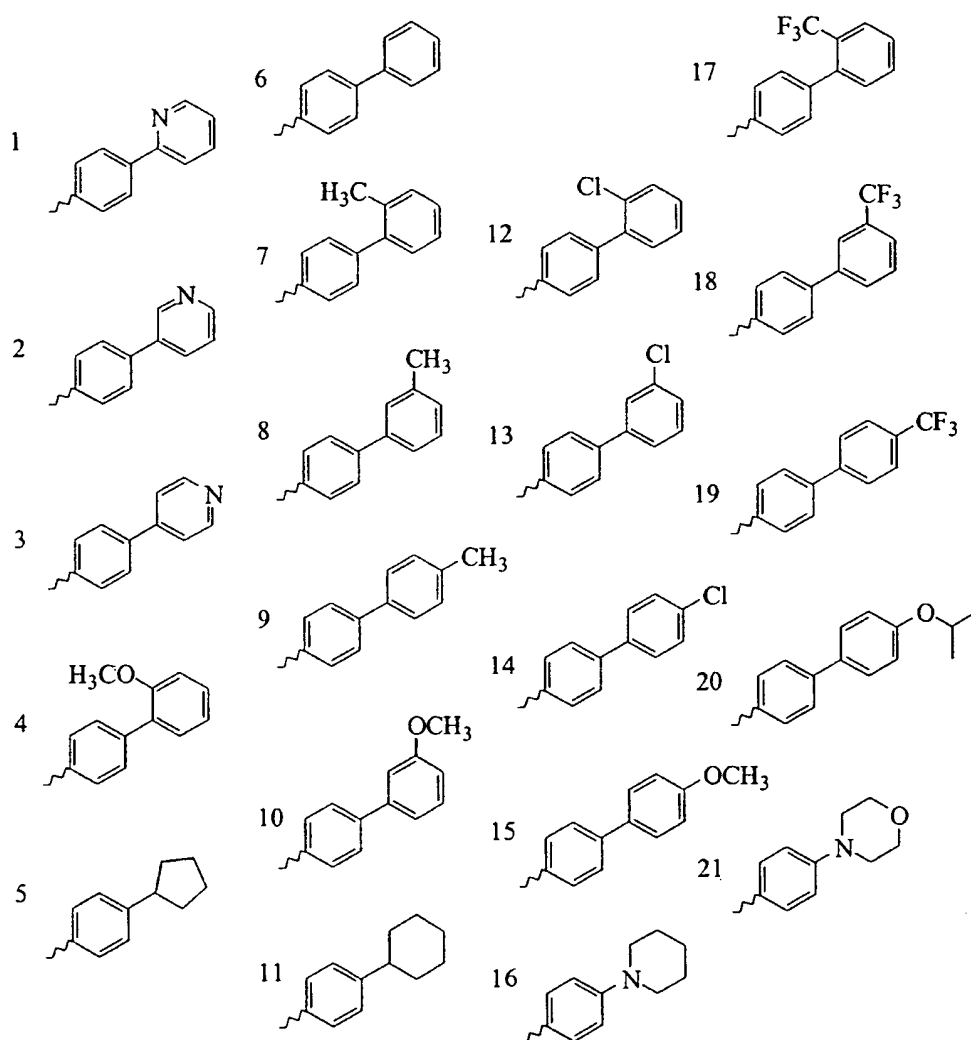
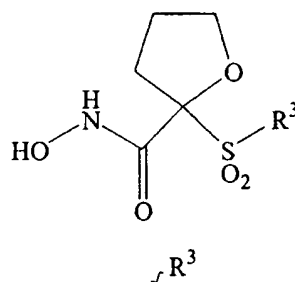
- 190 -

Table 61



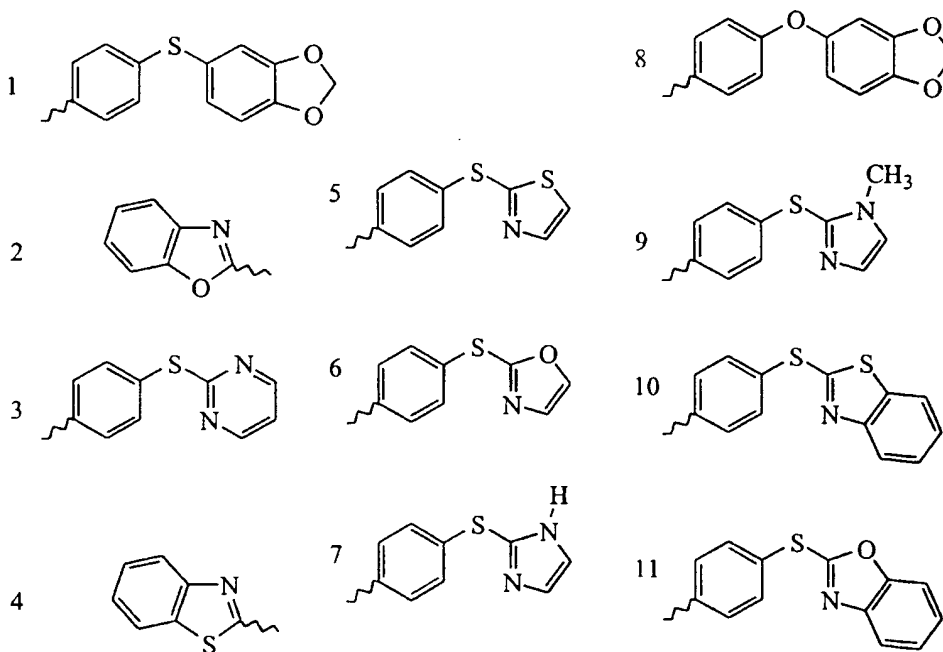
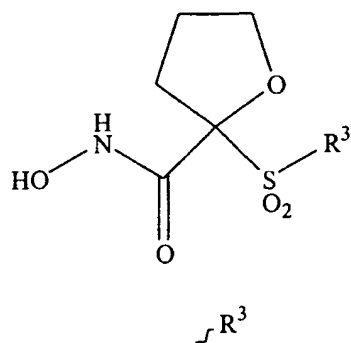
-191-

Table 62



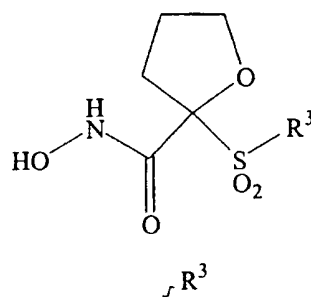
-192-

Table 63



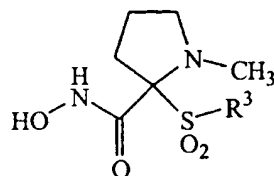
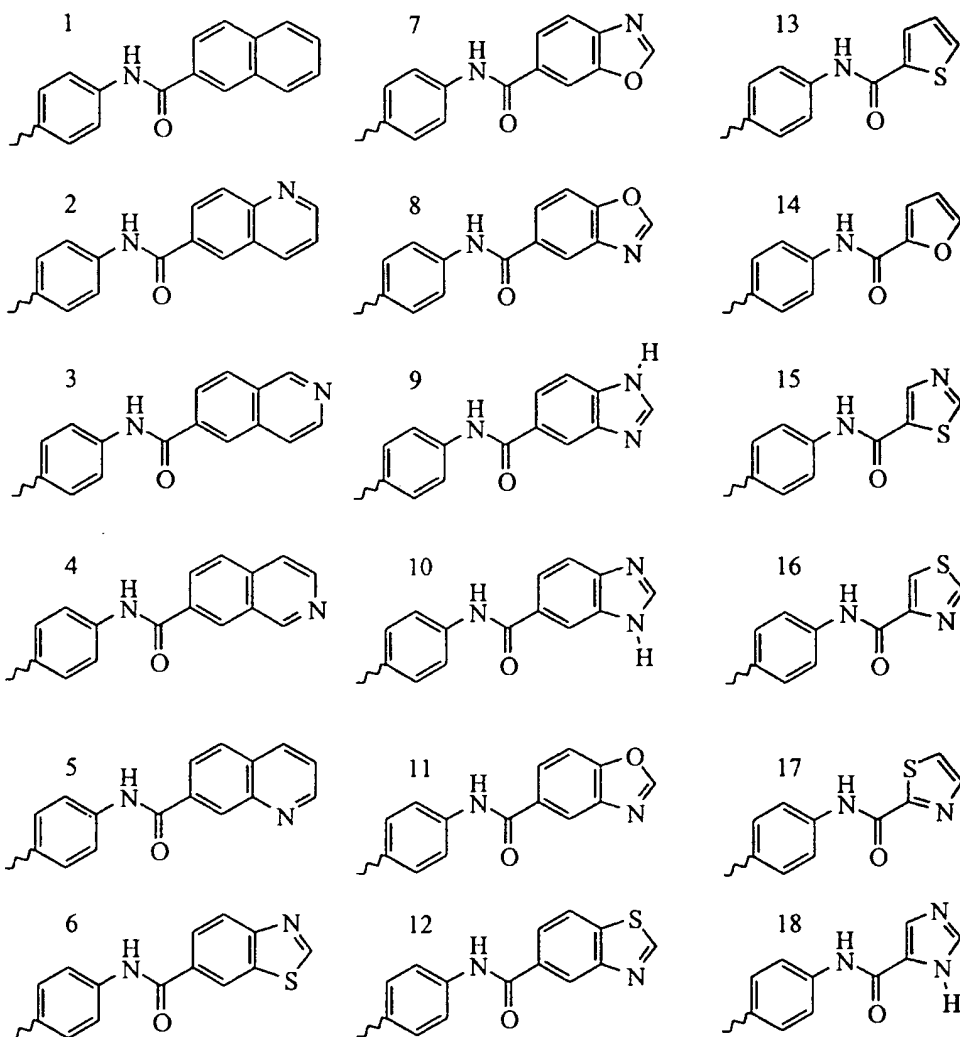
- 193 -

Table 64



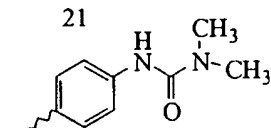
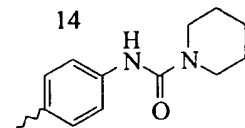
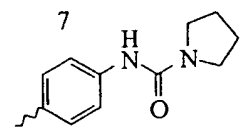
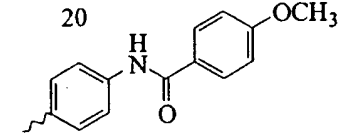
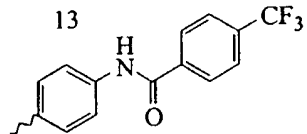
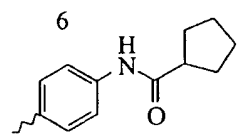
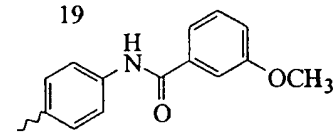
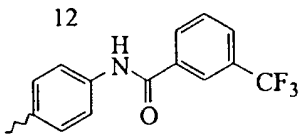
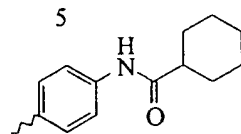
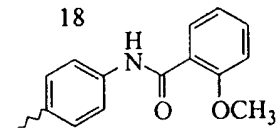
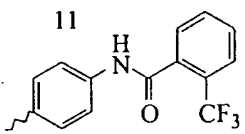
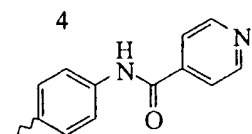
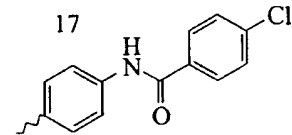
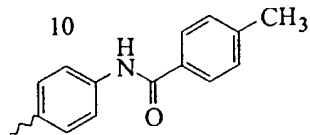
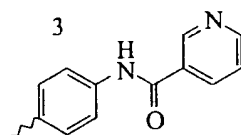
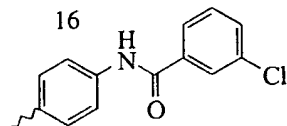
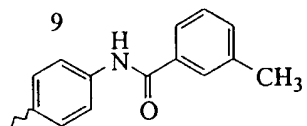
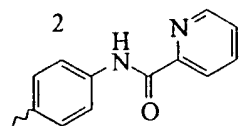
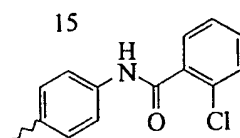
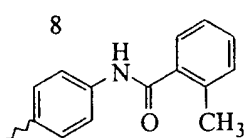
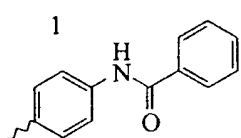
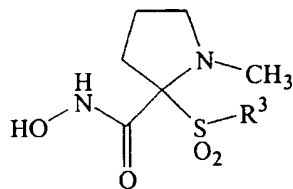
1	8	15
2	9	16
3	10	17
4	11	18
5	12	19
6	13	20
7	14	21

Table 65

 R^3 

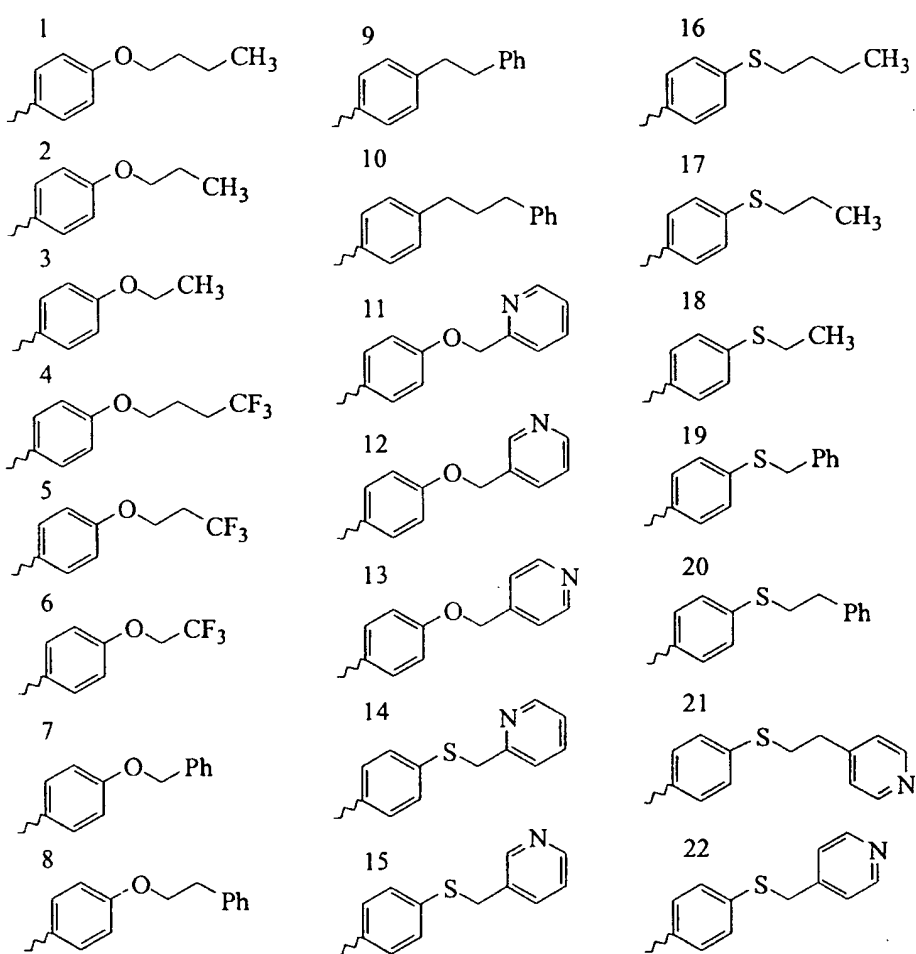
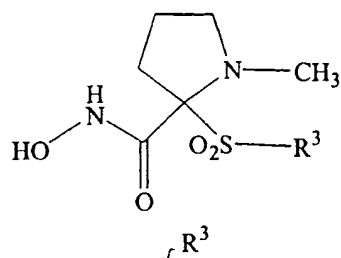
-195-

Table 66



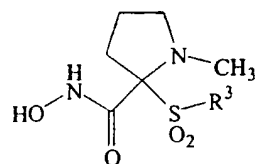
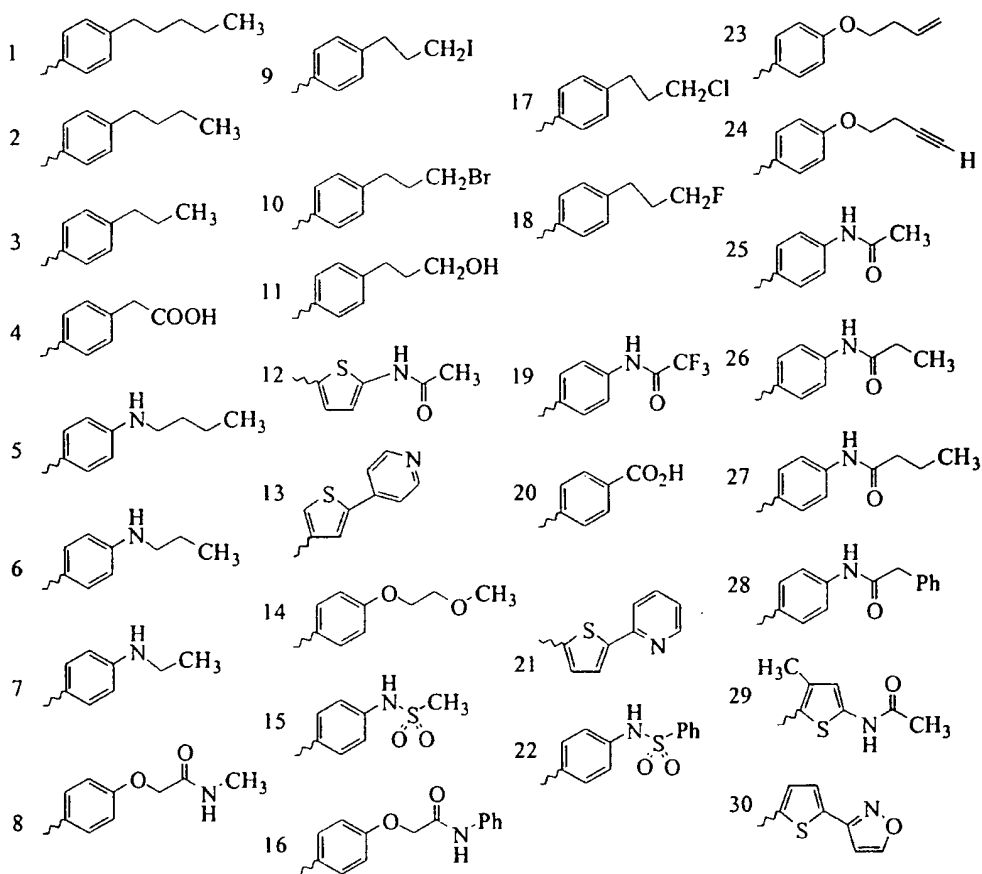
SUBSTITUTE SHEET (RULE 26)

Table 67



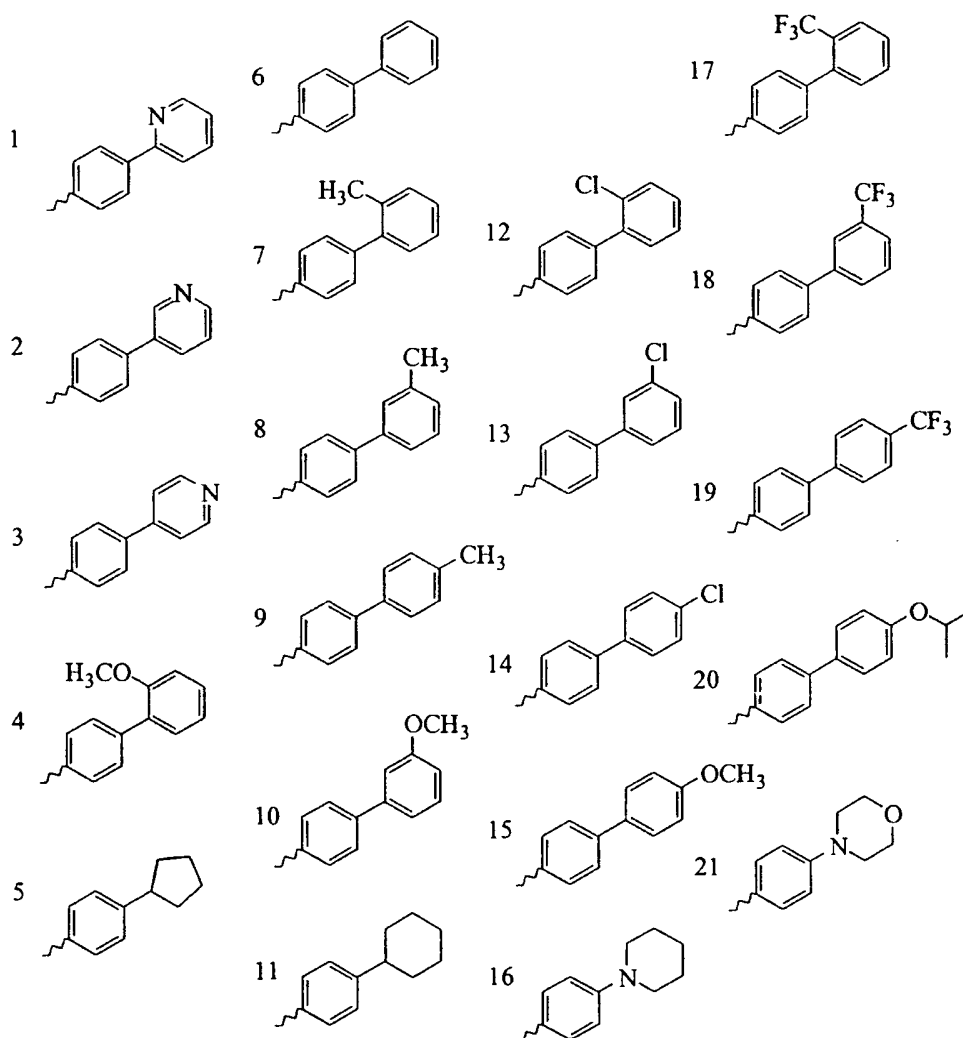
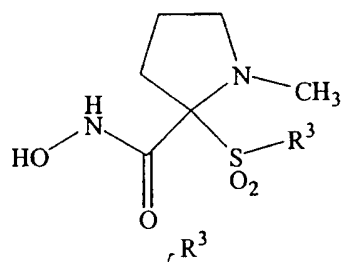
-197-

Table 68

 R^3 

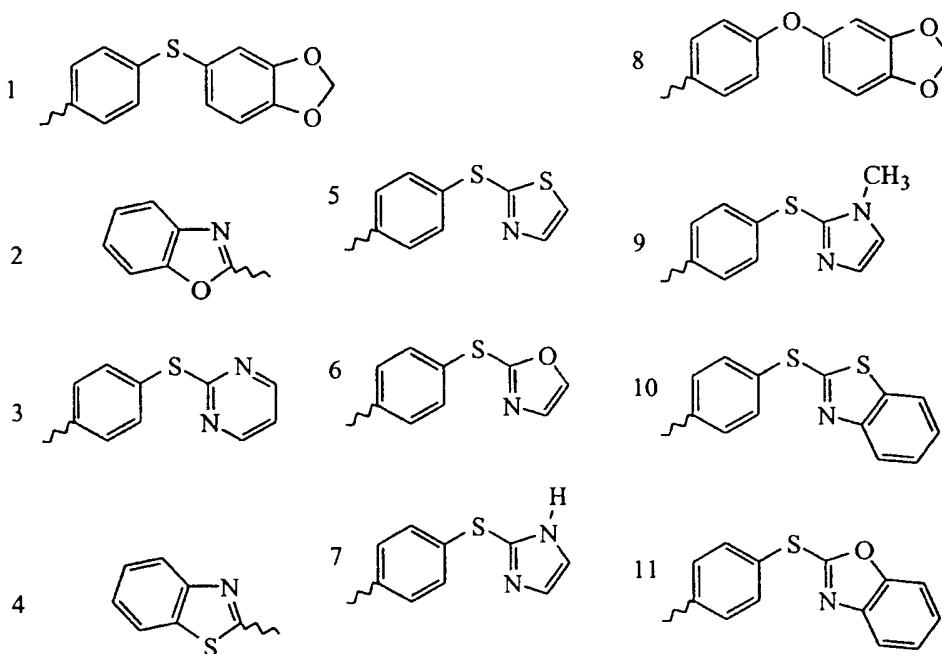
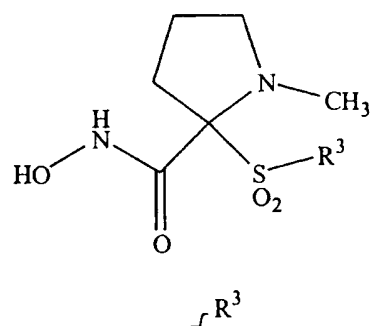
- 198 -

Table 69



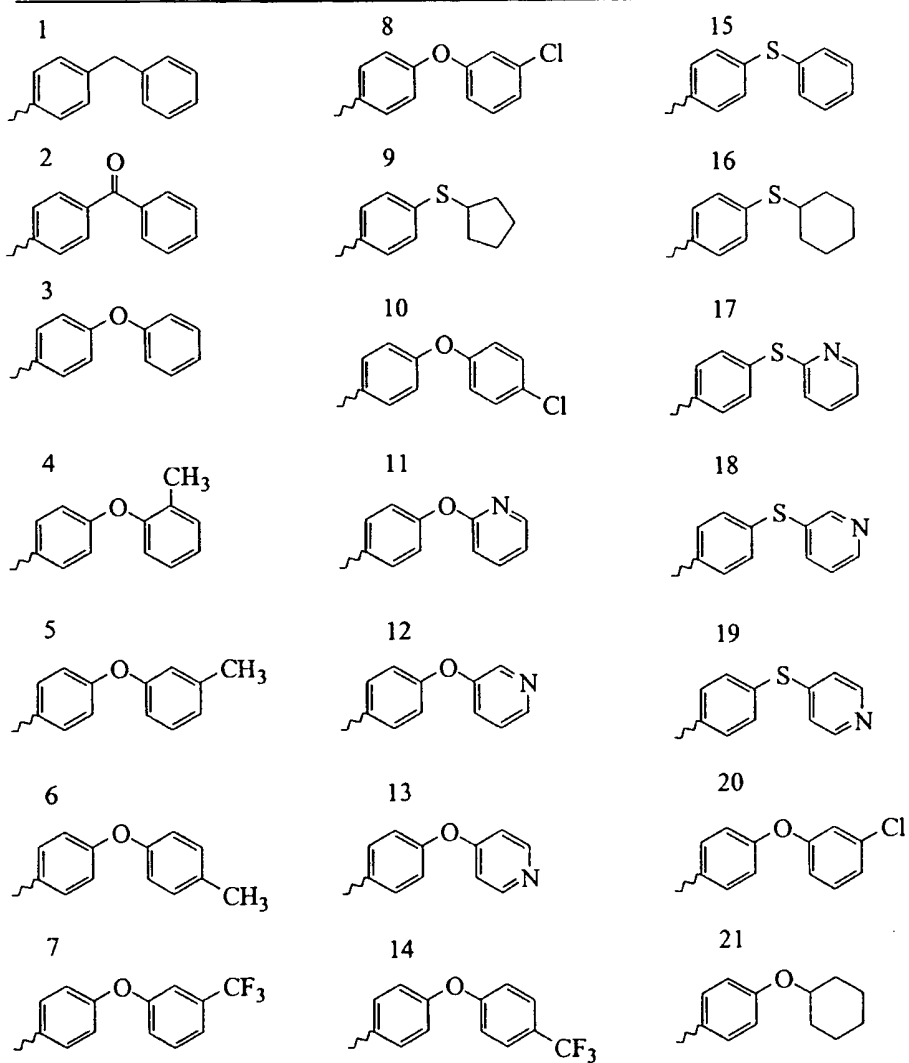
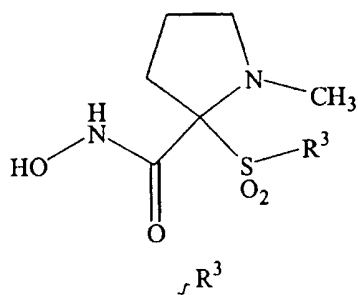
- 199 -

Table 70



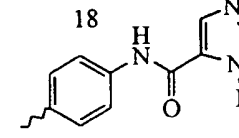
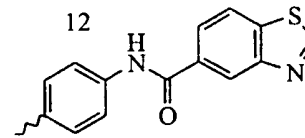
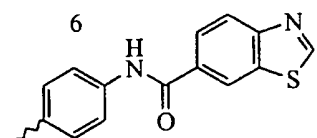
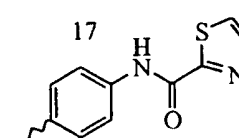
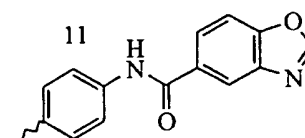
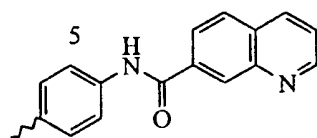
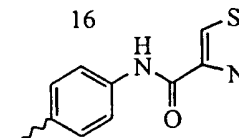
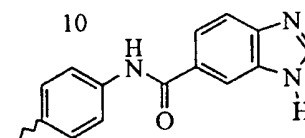
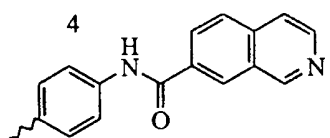
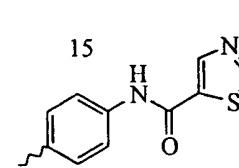
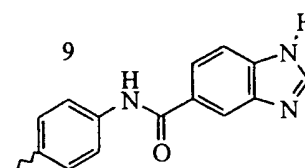
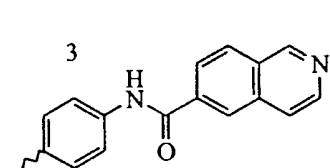
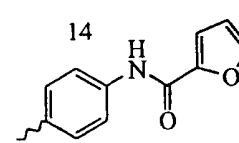
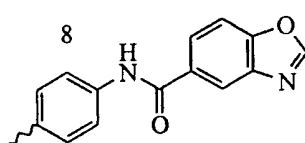
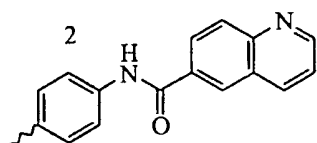
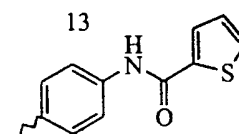
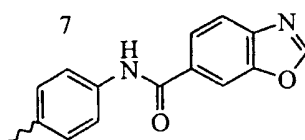
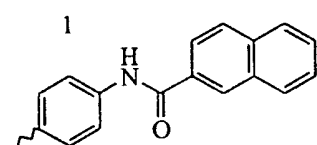
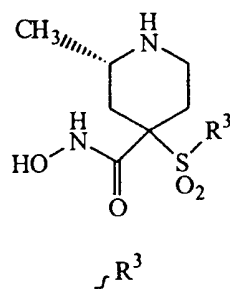
-200-

Table 71



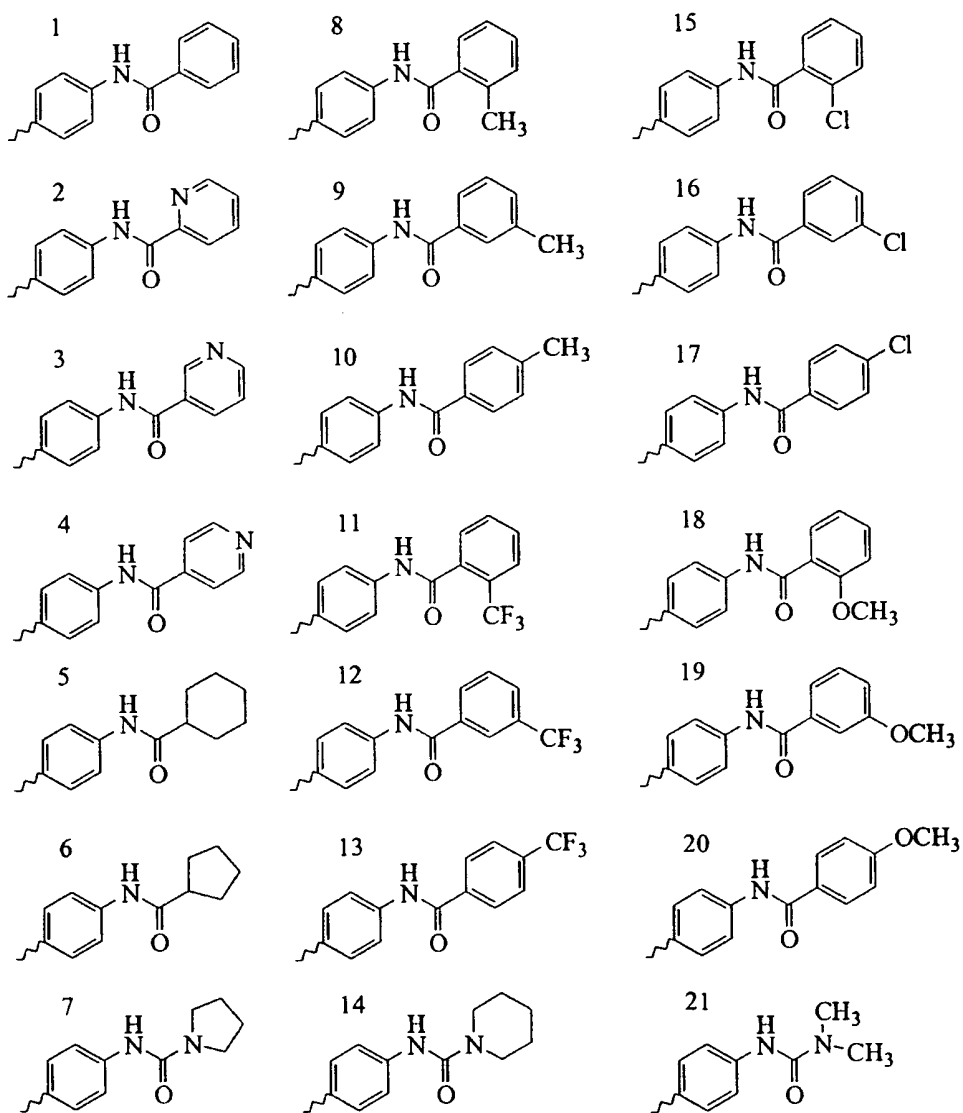
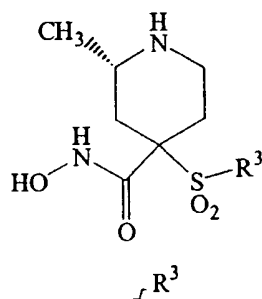
- 201 -

Table 72



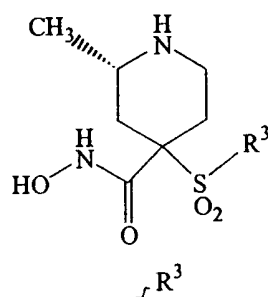
- 202 -

Table 73



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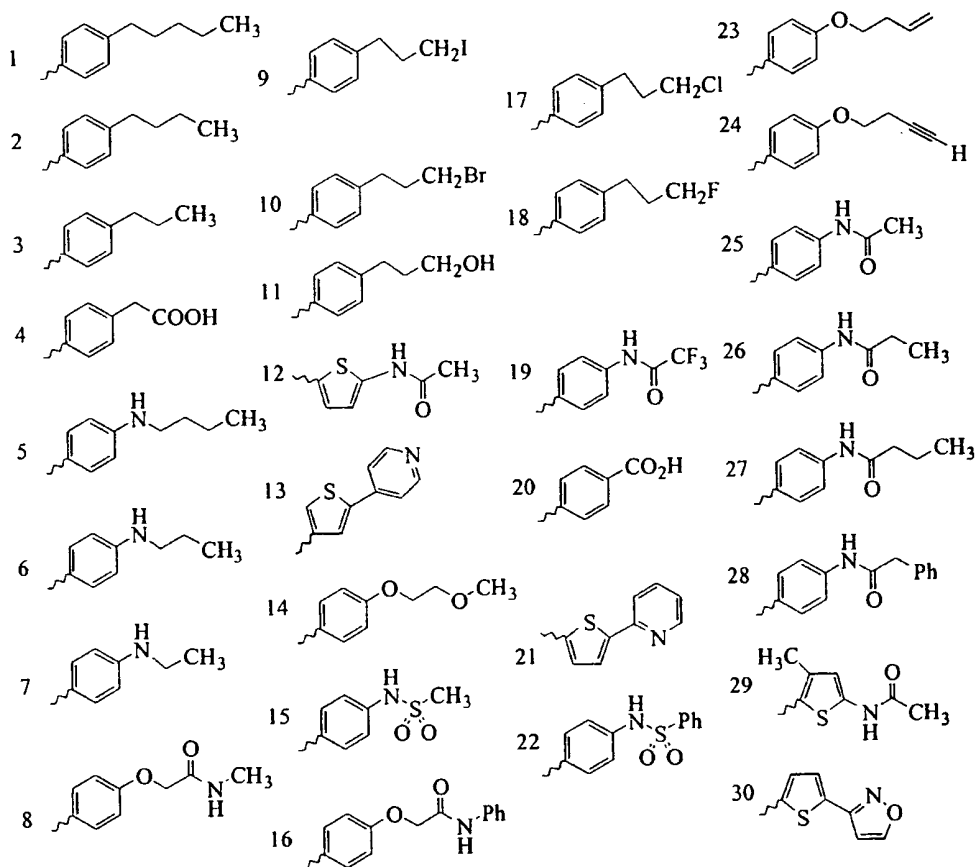
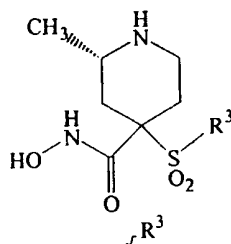
Table 74



1 	9 	16
2 	10 	17
3 	11 	18
4 	12 	19
5 	13 	20
6 	14 	21
7 	15 	22
8 		

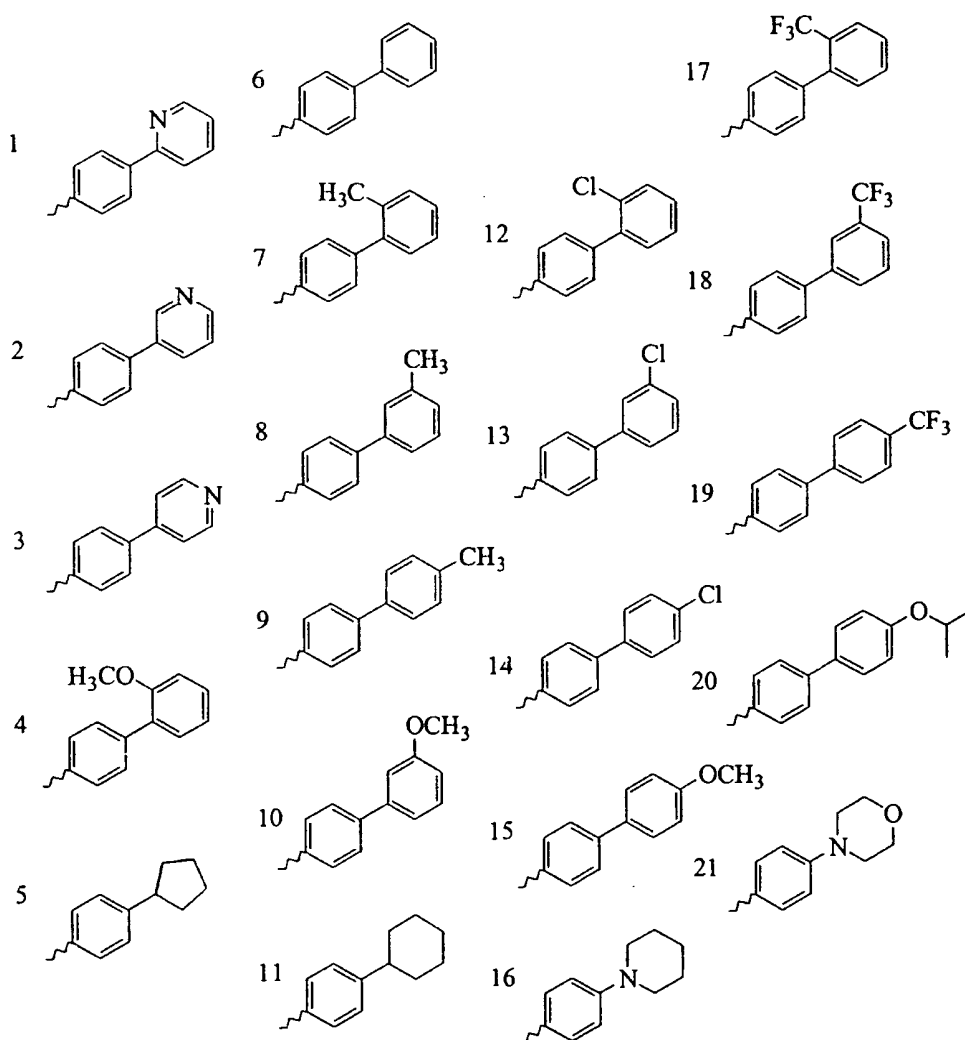
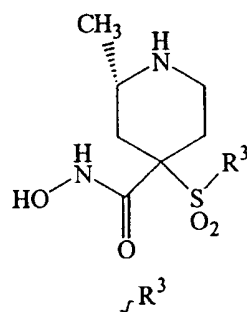
- 204 -

Table 75



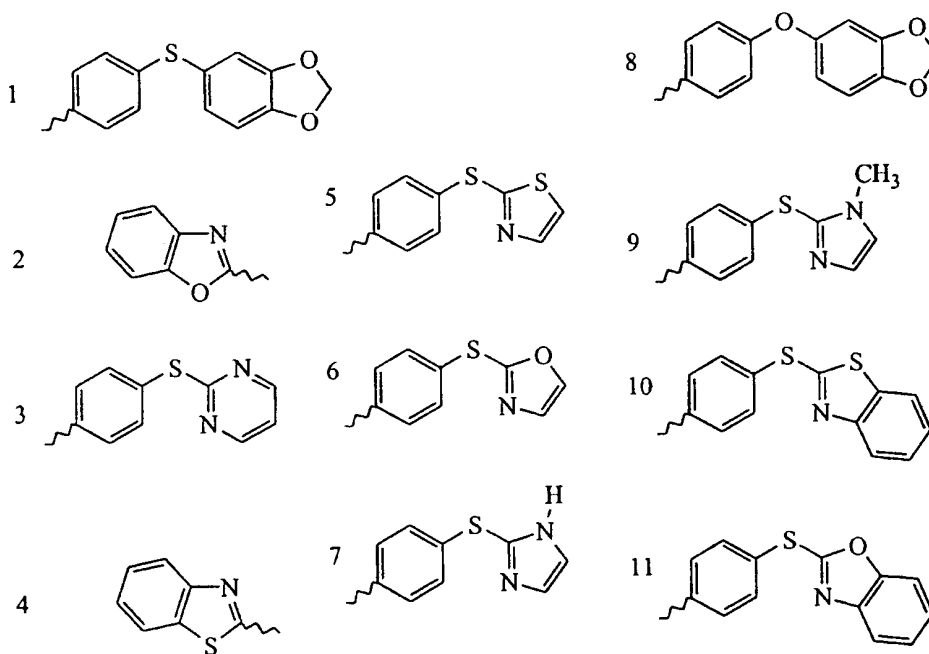
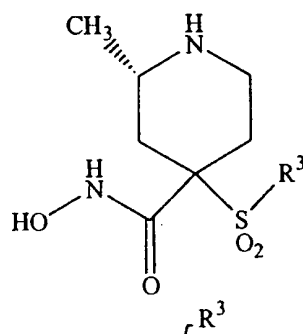
-205-

Table 76



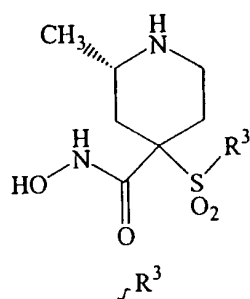
-206-

Table 77



- 207 -

Table 78



1 	8 	15
2 	9 	16
3 	10 	17
4 	11 	18
5 	12 	19
6 	13 	20
7 	14 	21

-208-

Table 79

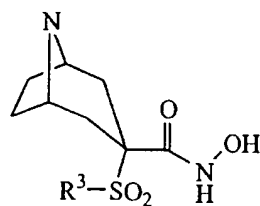
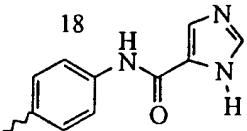
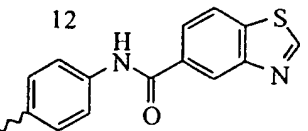
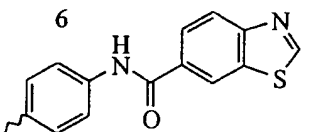
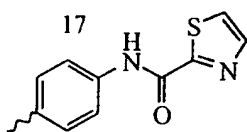
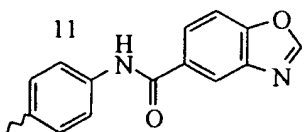
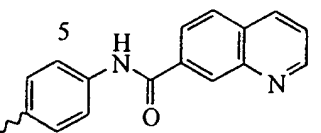
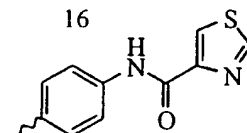
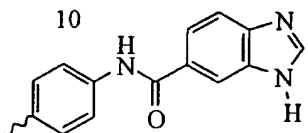
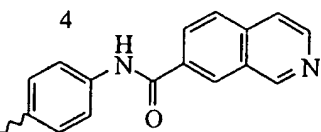
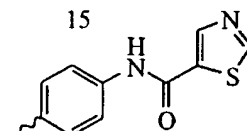
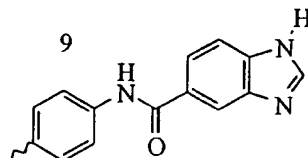
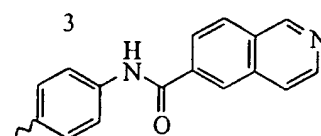
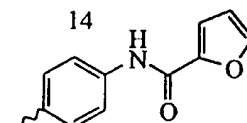
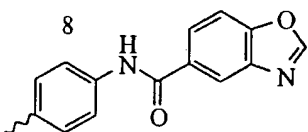
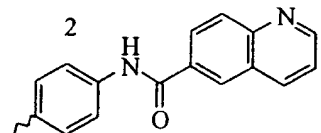
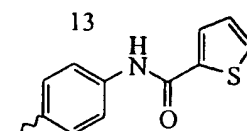
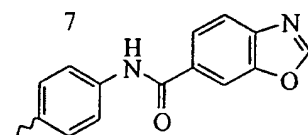
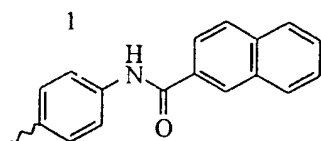
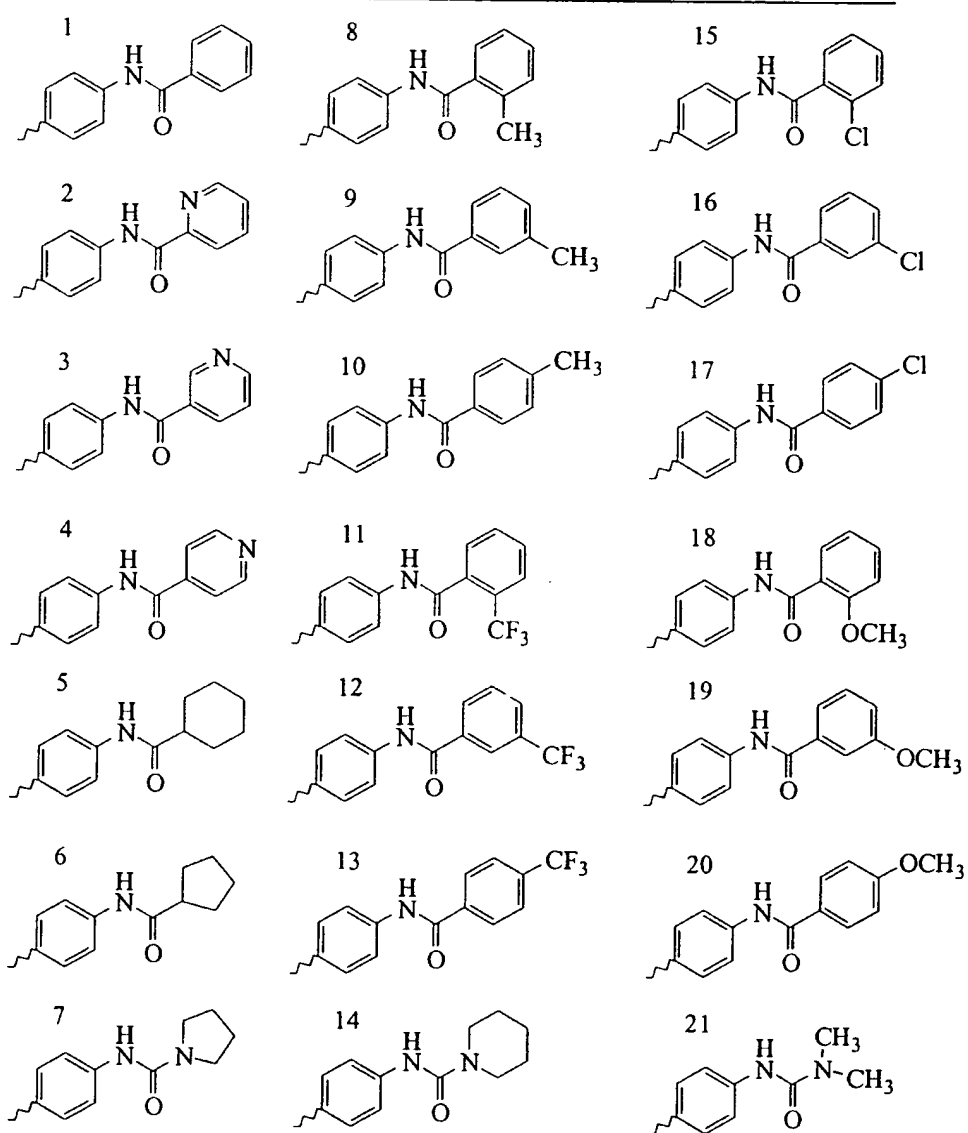
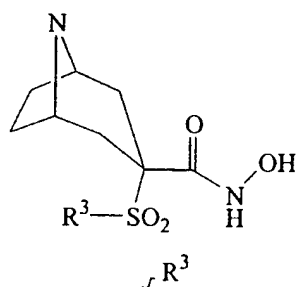
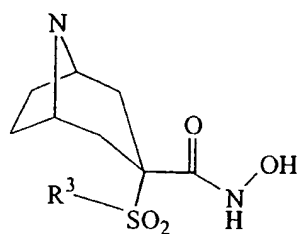
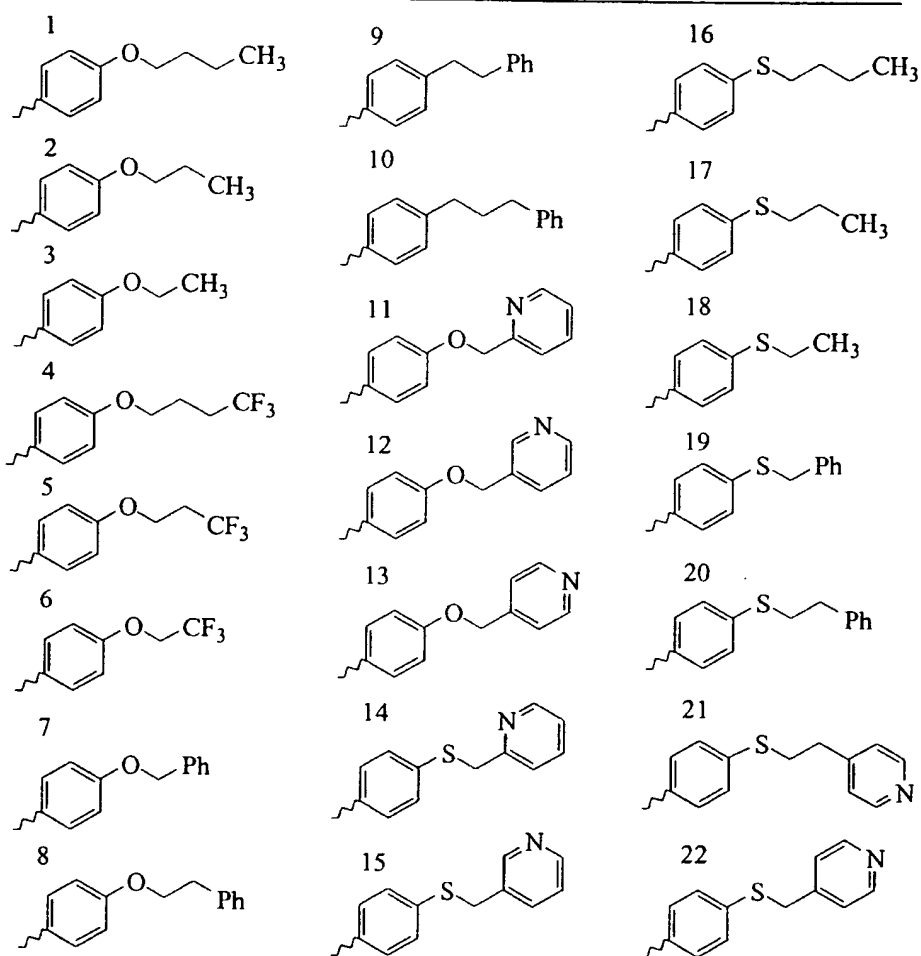
 R^3 

Table 80



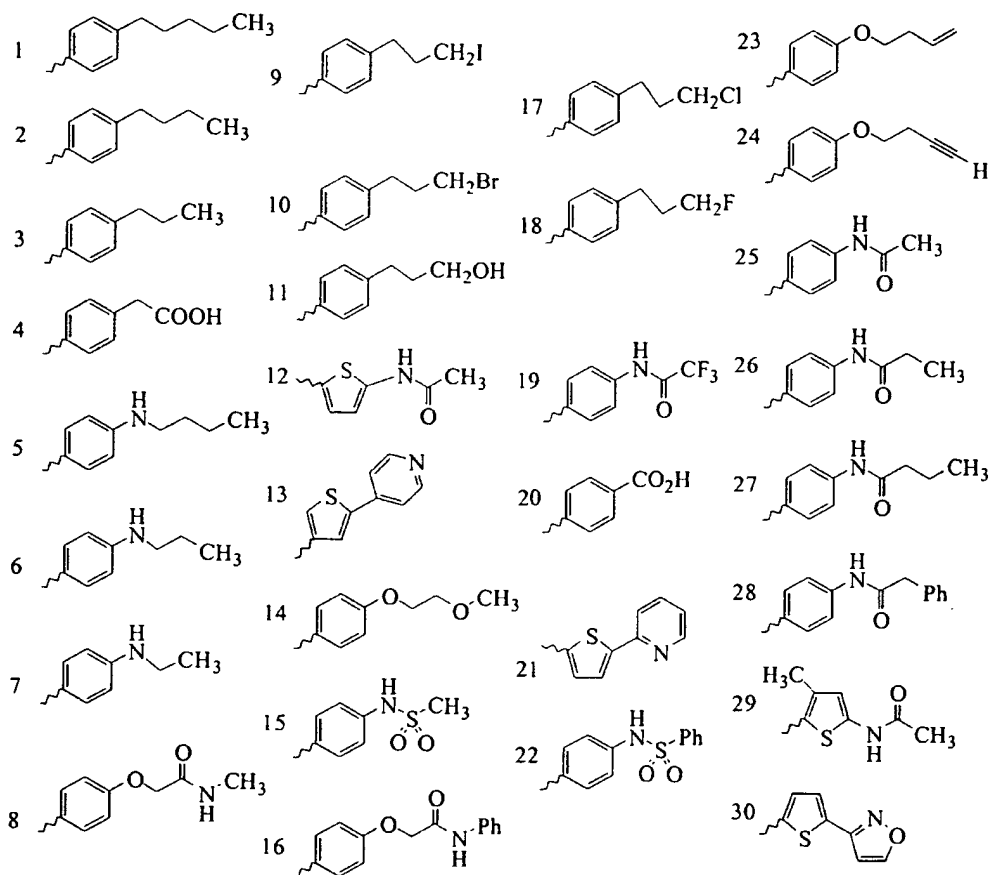
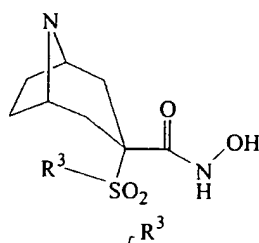
- 210 -

Table 81

 R^3 

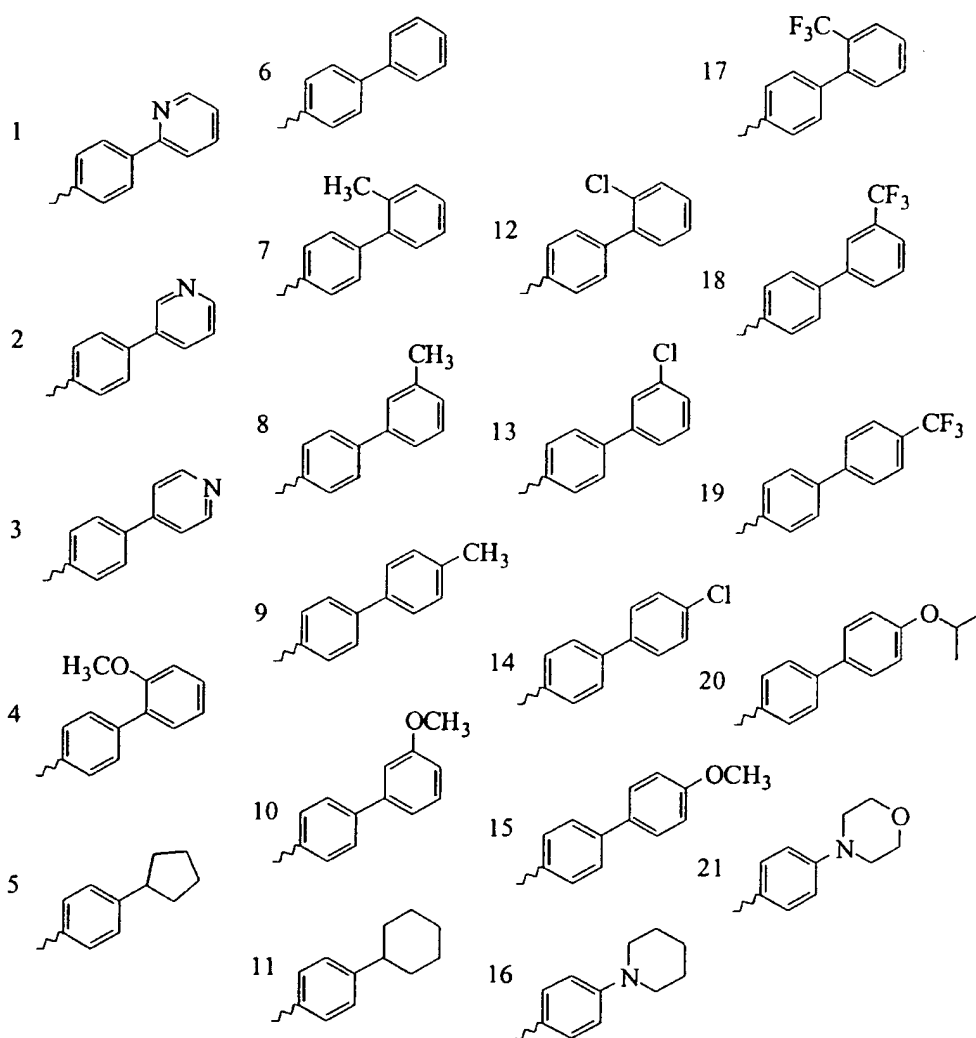
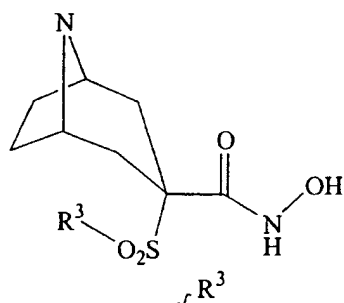
- 211 -

Table 82



- 212 -

Table 83



- 213 -

Table 84

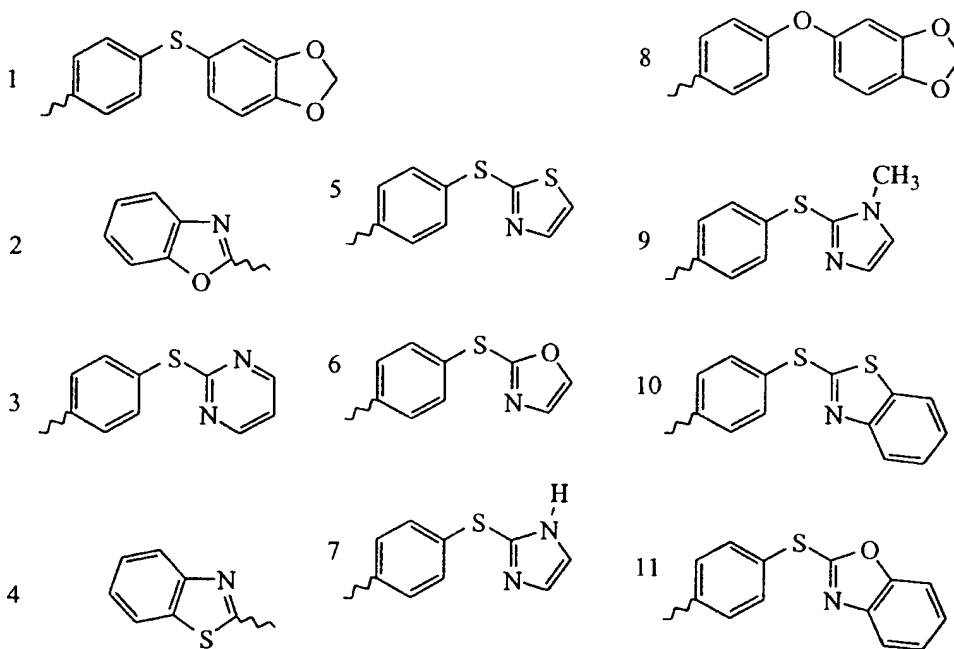
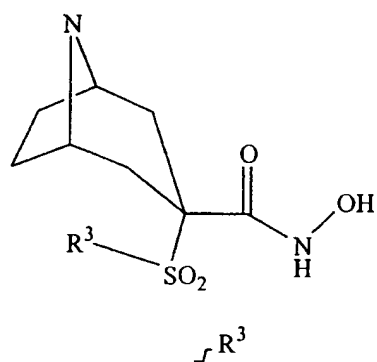
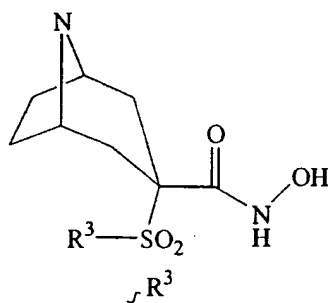


Table 85



1	8	15
2	9	16
3	10	17
4	11	18
5	12	19
6	13	20
7	14	21

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Table 86

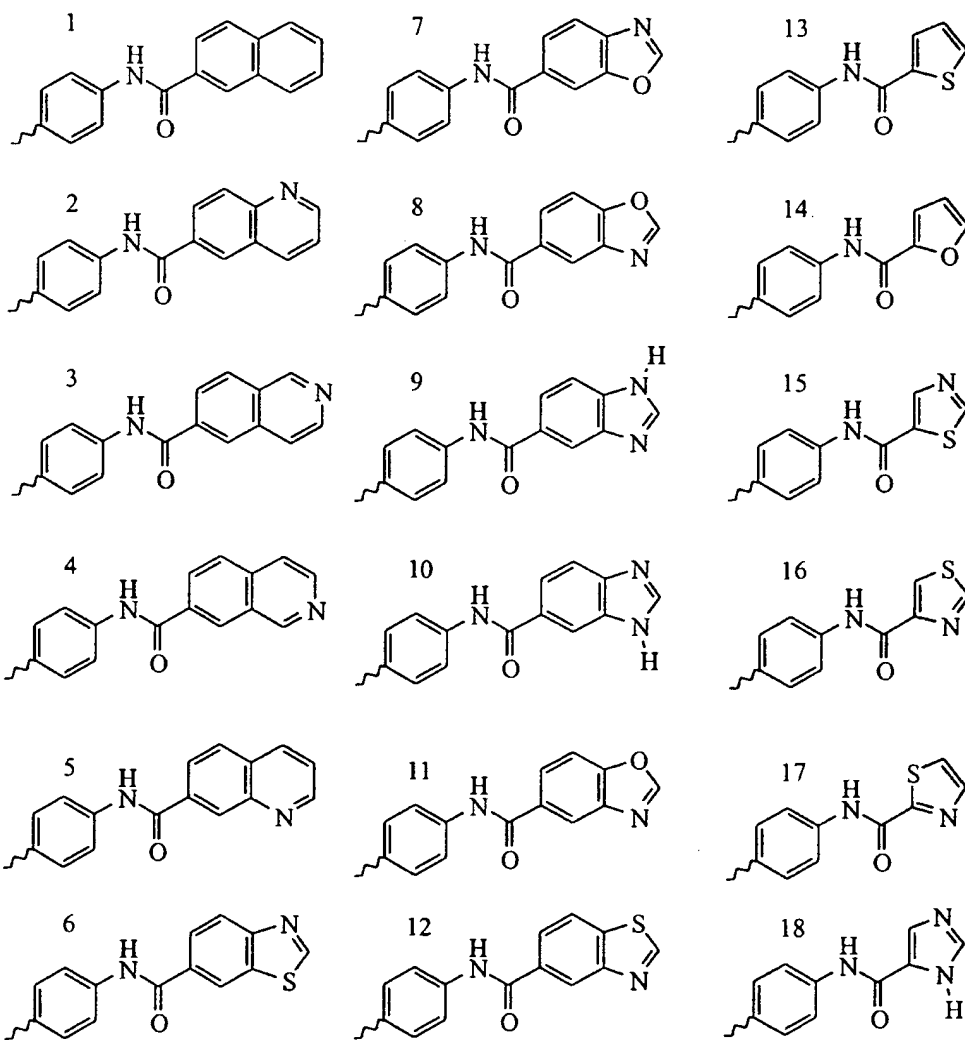
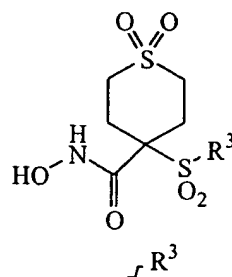
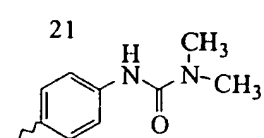
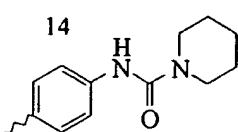
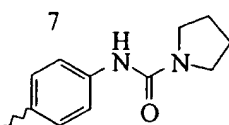
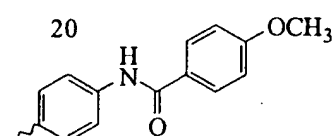
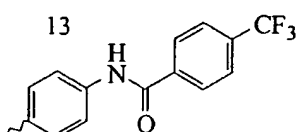
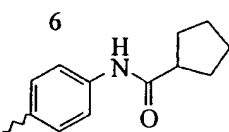
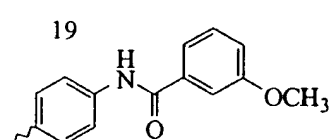
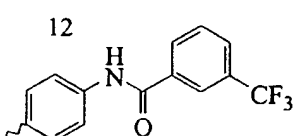
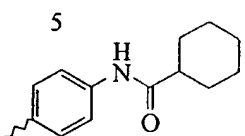
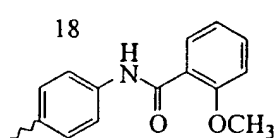
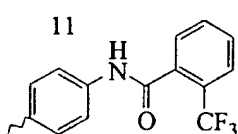
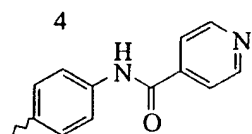
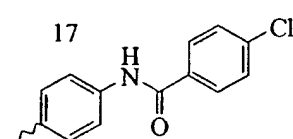
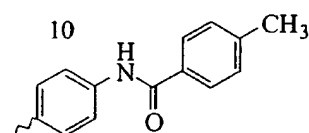
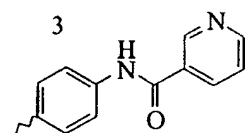
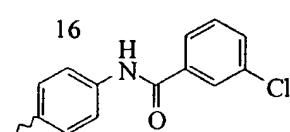
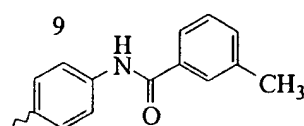
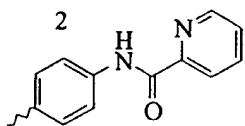
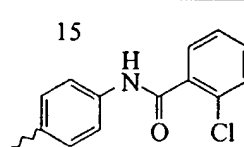
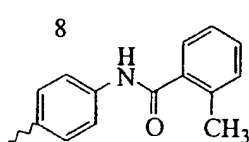
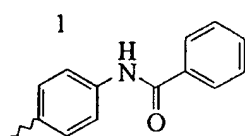
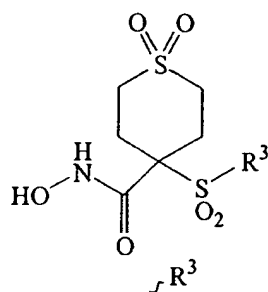
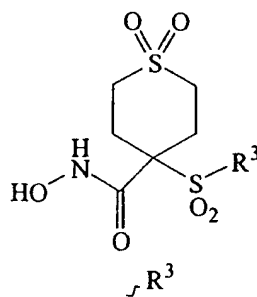


Table 87



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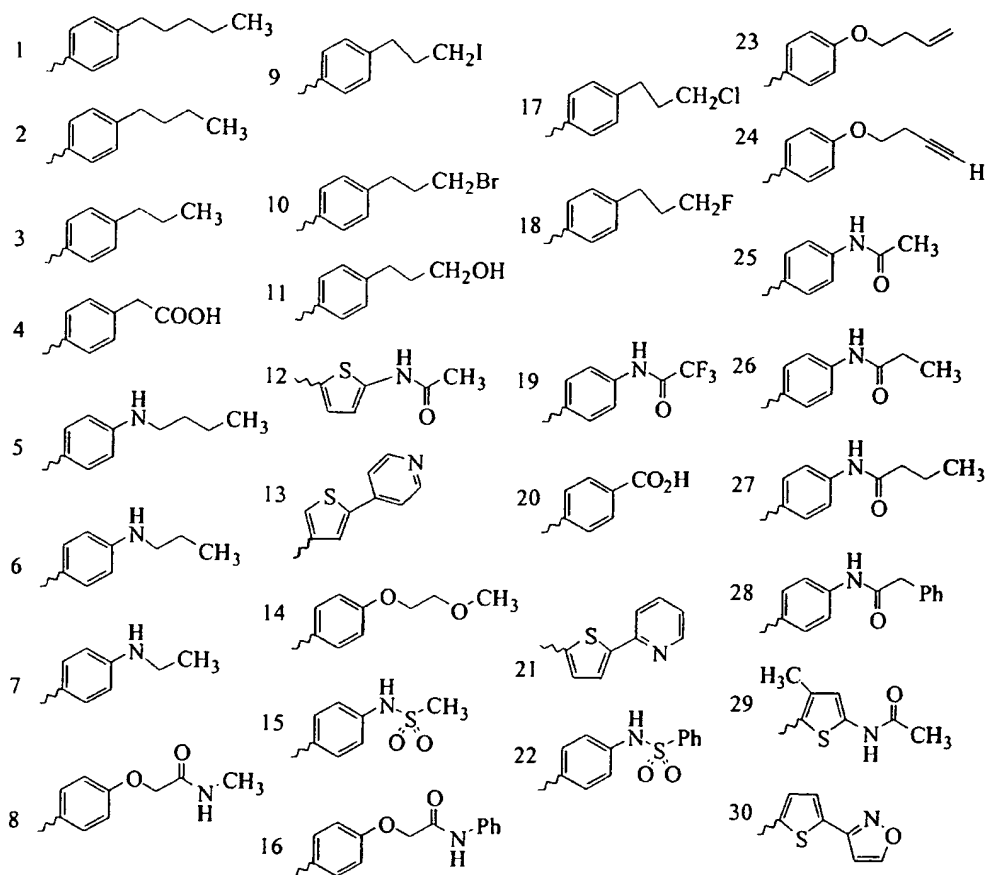
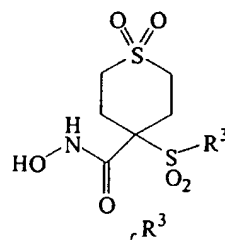
Table 88



1 	9 	16
2 	10 	17
3 	11 	18
4 	12 	19
5 	13 	20
6 	14 	21
7 	15 	22
8 		

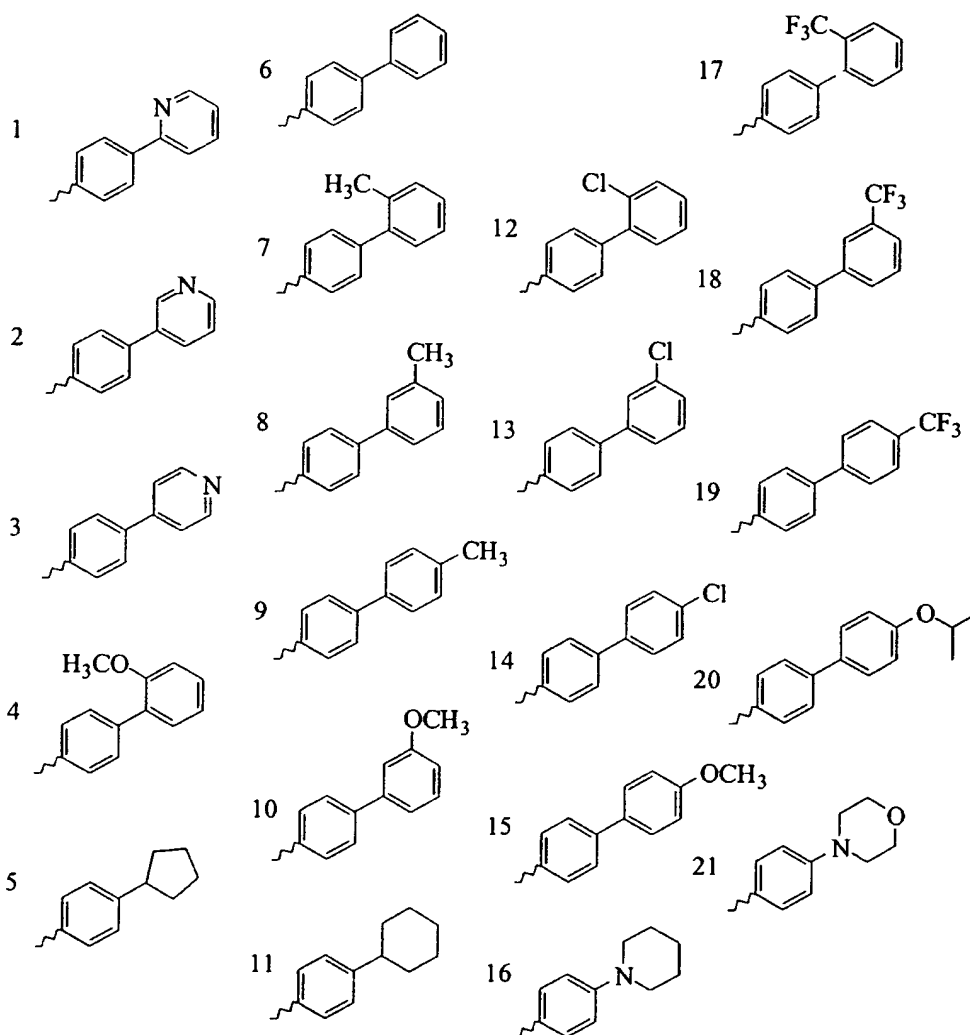
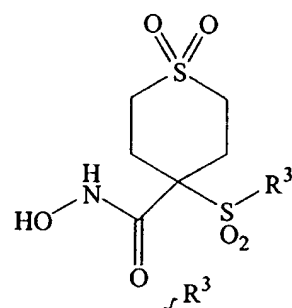
- 218 -

Table 89



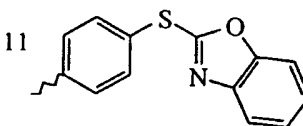
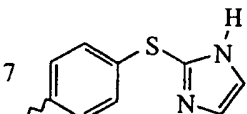
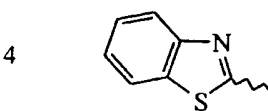
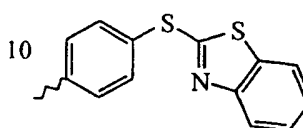
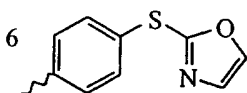
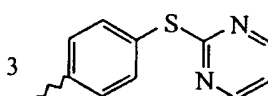
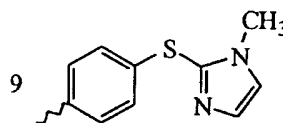
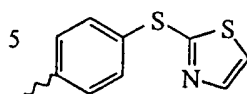
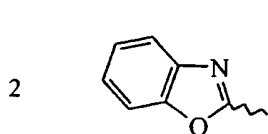
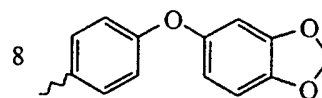
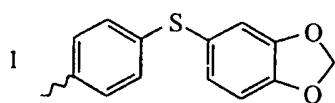
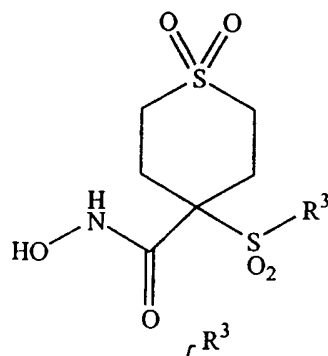
- 219 -

Table 90



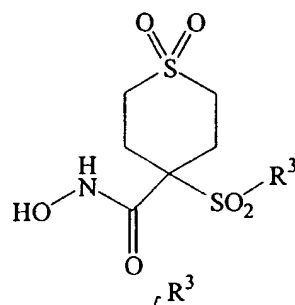
- 220 -

Table 91



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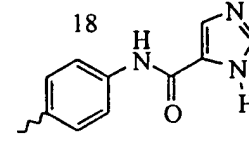
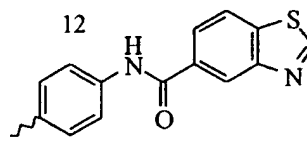
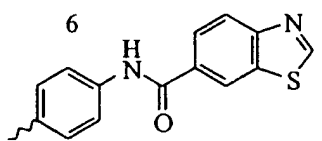
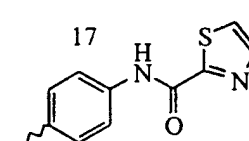
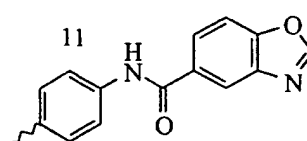
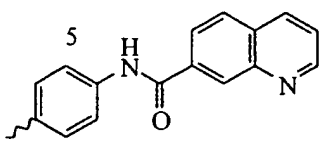
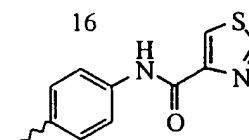
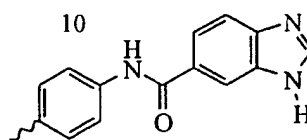
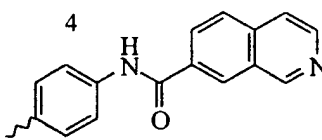
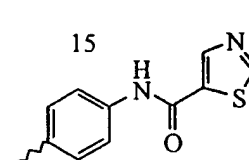
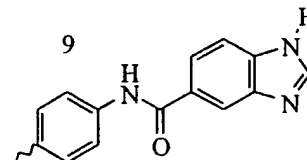
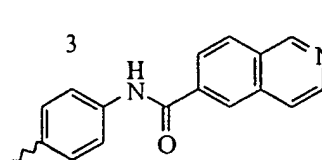
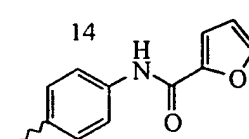
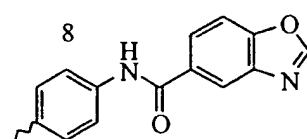
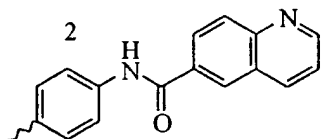
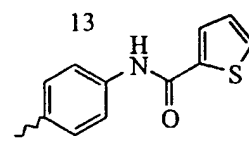
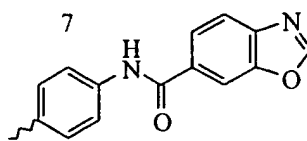
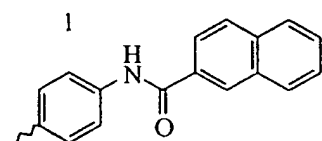
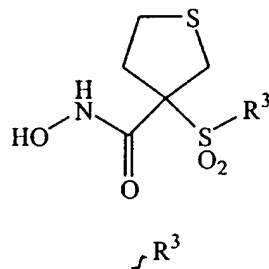
Table 92



1	8	15
2	9	16
3	10	17
4	11	18
5	12	19
6	13	20
7	14	21

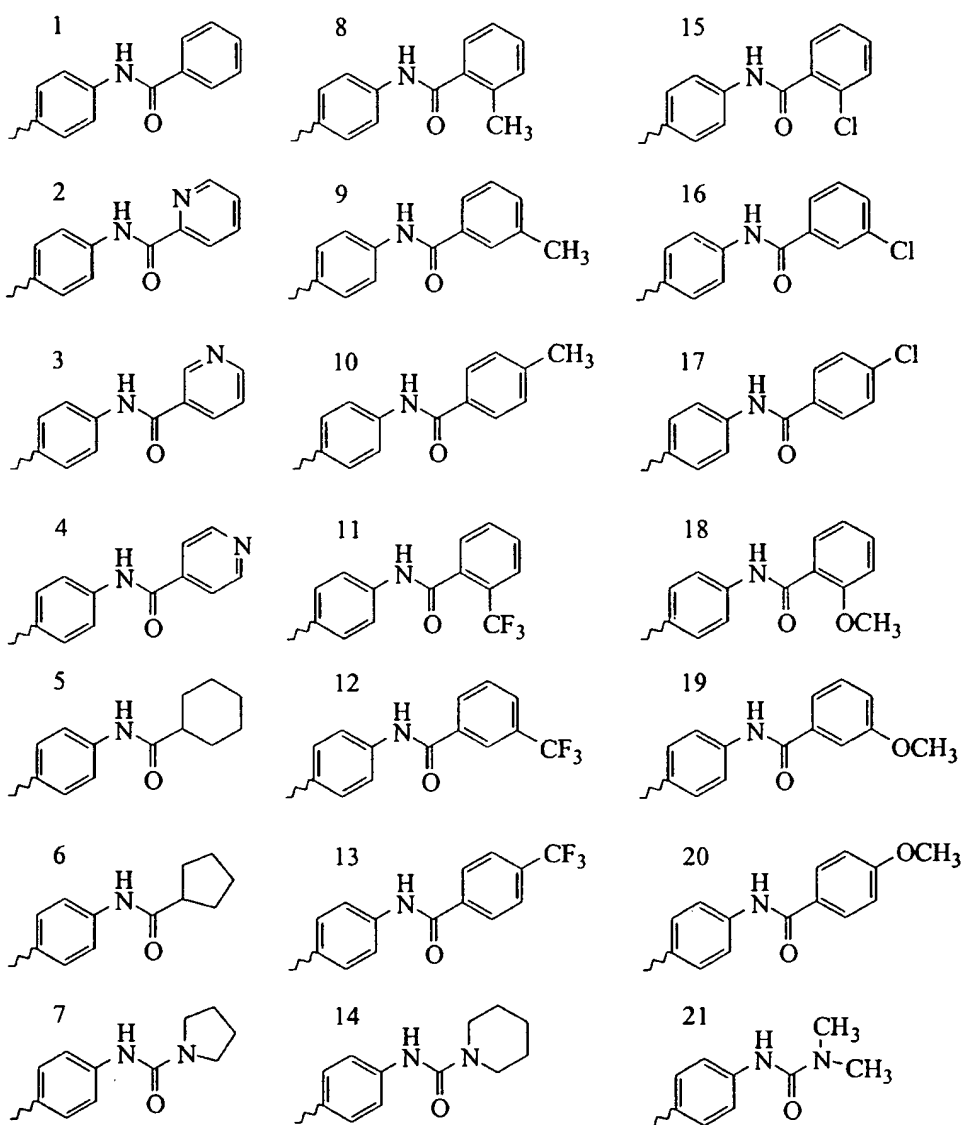
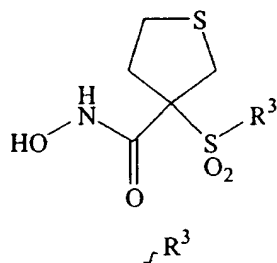
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Table 93



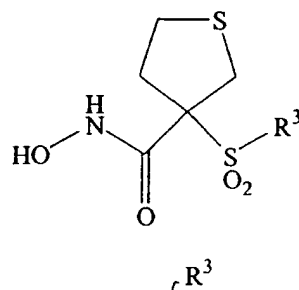
- 223 -

Table 94



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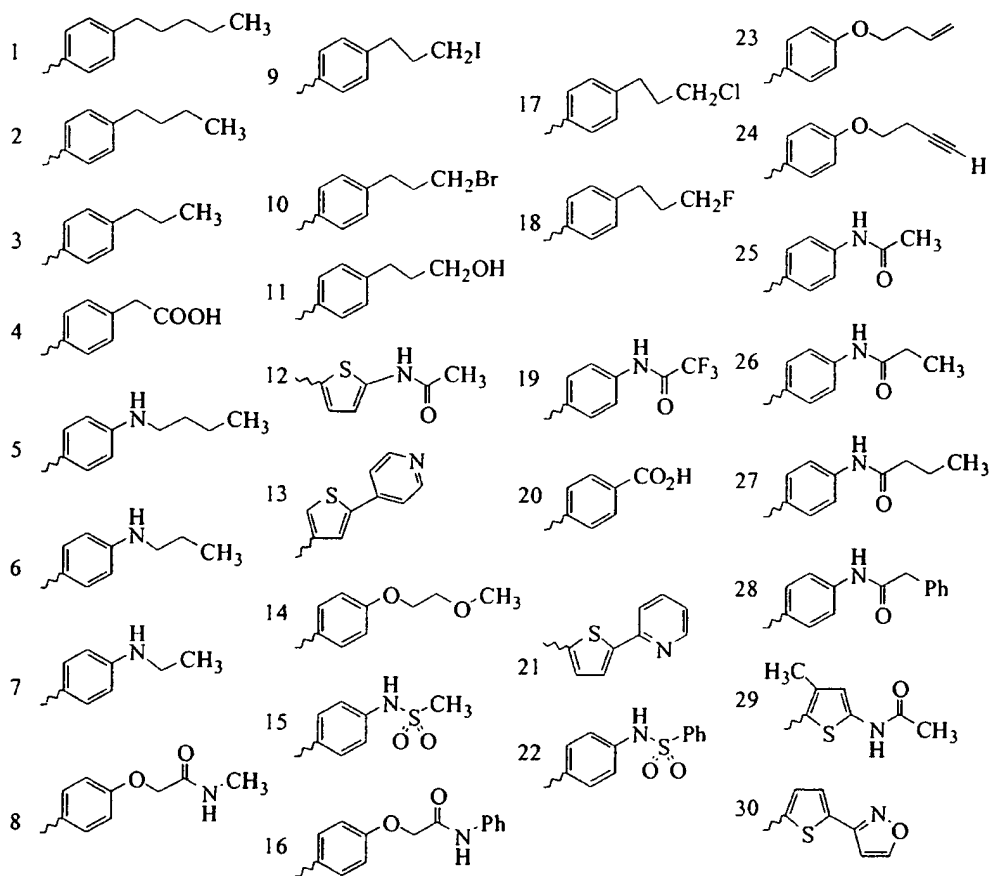
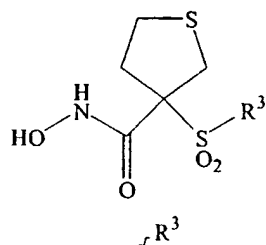
Table 95



1 	9 	16
2 	10 	17
3 	11 	18
4 	12 	19
5 	13 	20
6 	14 	21
7 	15 	22
8 		

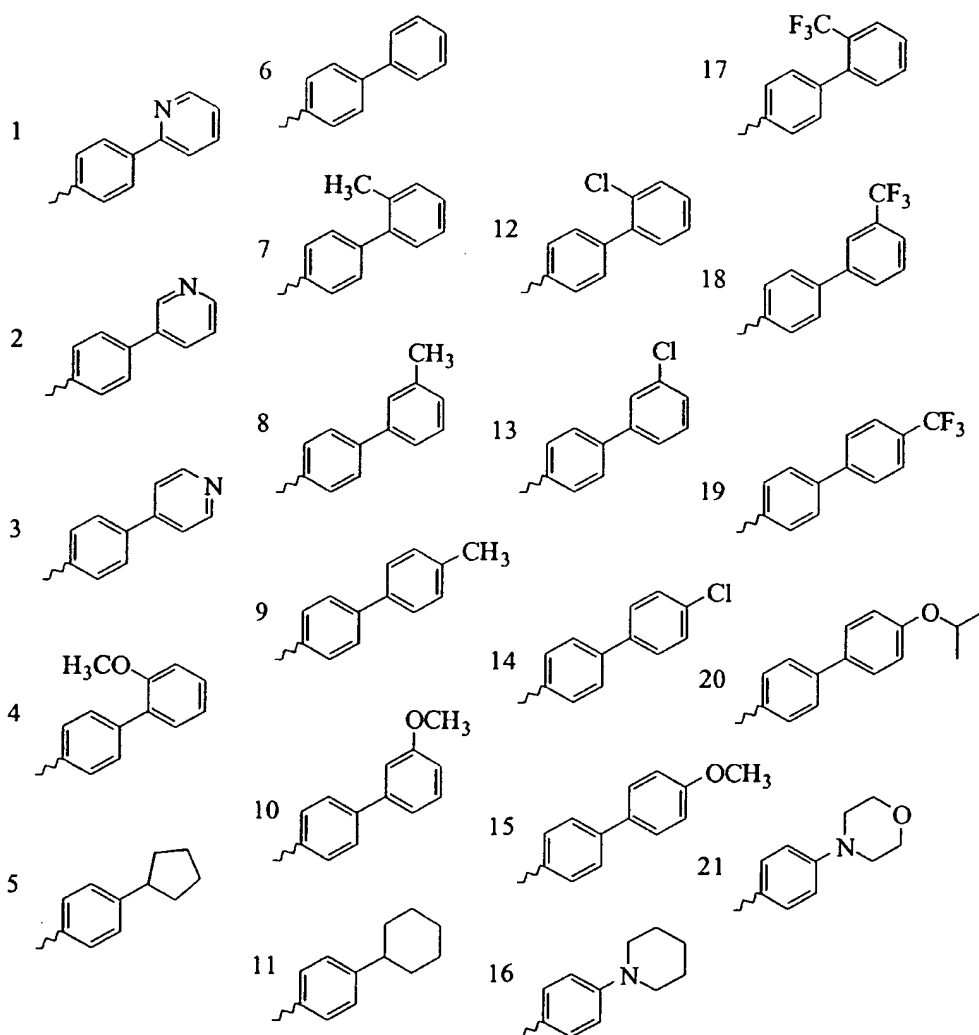
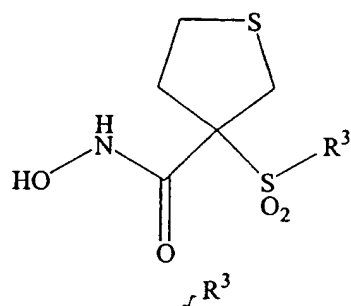
- 225 -

Table 96



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Table 97



- 227 -

Table 98

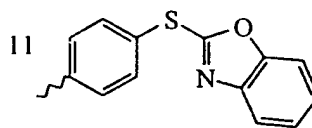
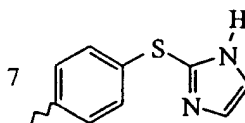
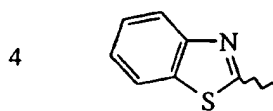
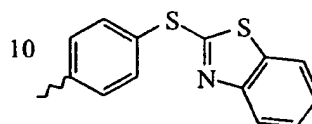
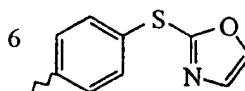
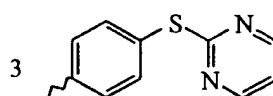
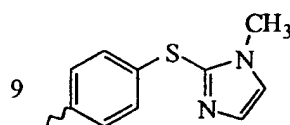
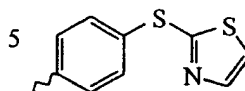
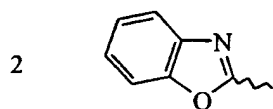
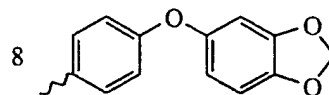
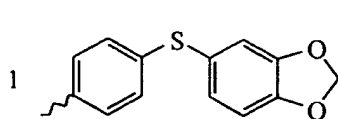
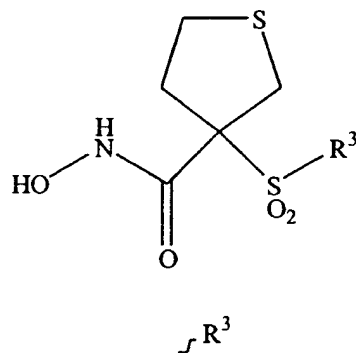
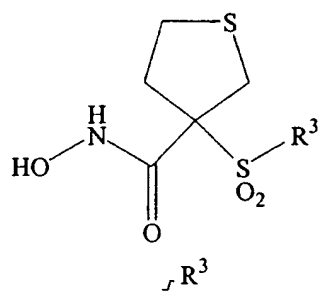


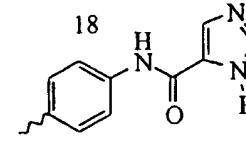
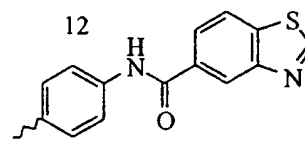
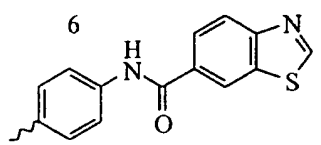
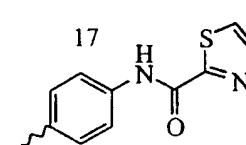
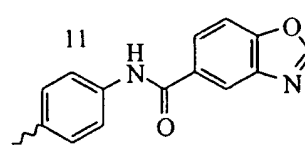
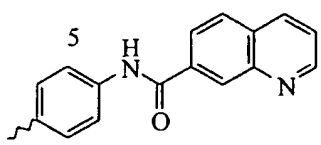
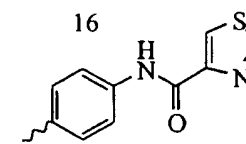
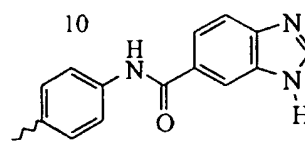
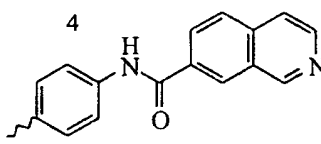
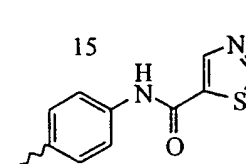
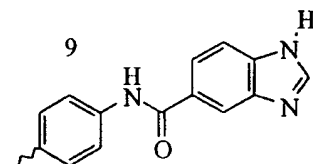
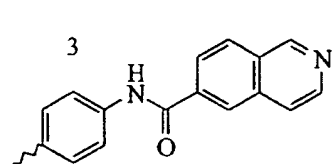
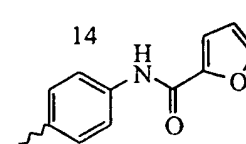
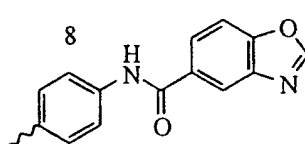
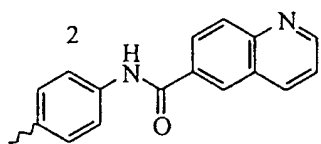
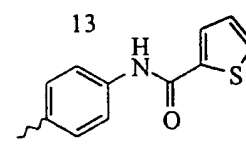
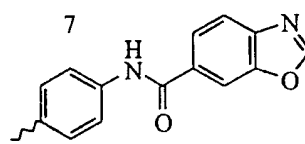
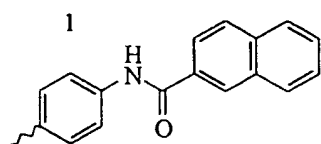
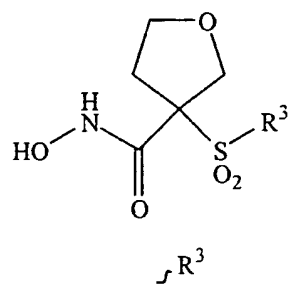
Table 99



1	8	15
2	9	16
3	10	17
4	11	18
5	12	19
6	13	20
7	14	21

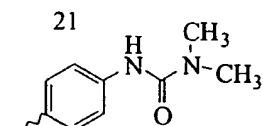
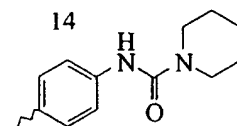
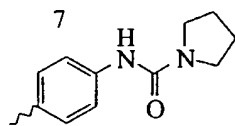
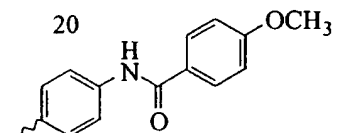
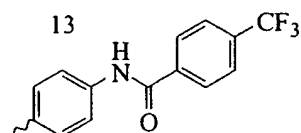
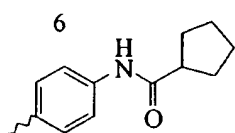
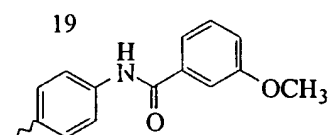
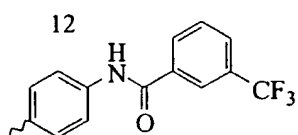
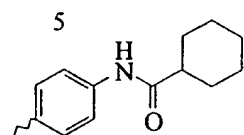
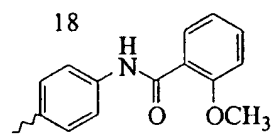
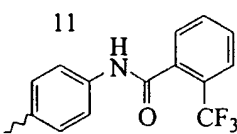
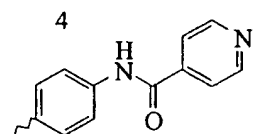
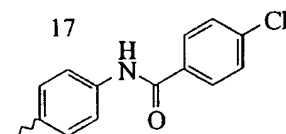
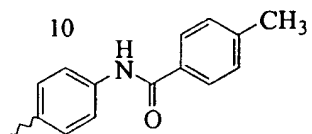
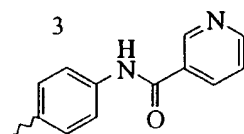
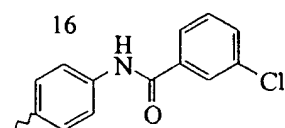
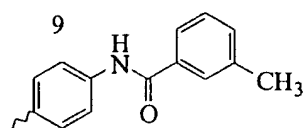
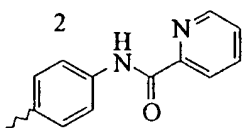
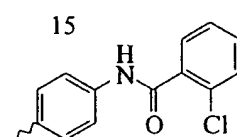
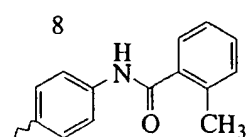
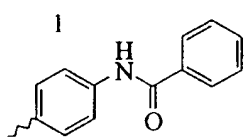
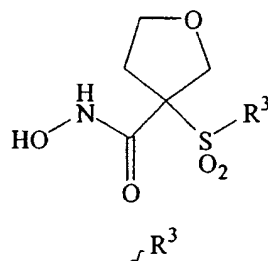
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Table 100



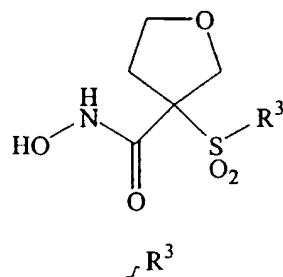
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Table 101

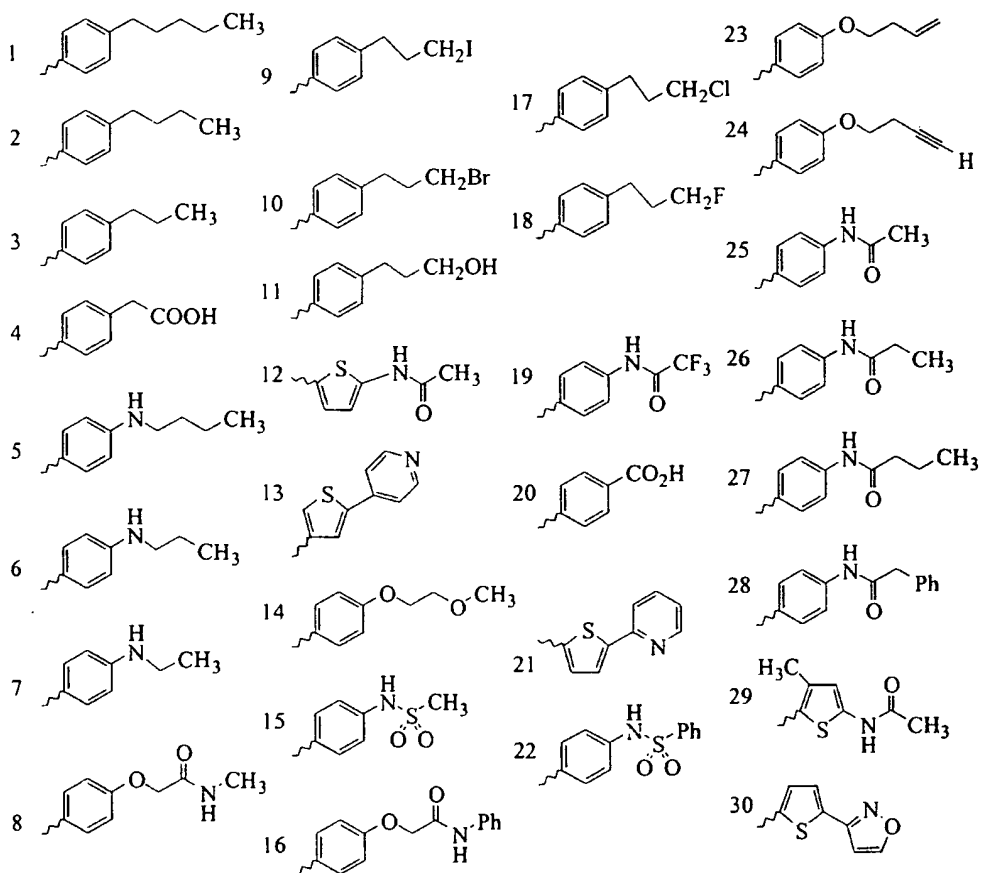
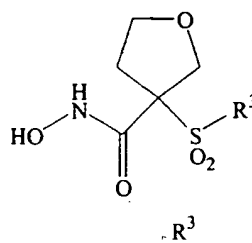


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Table 102

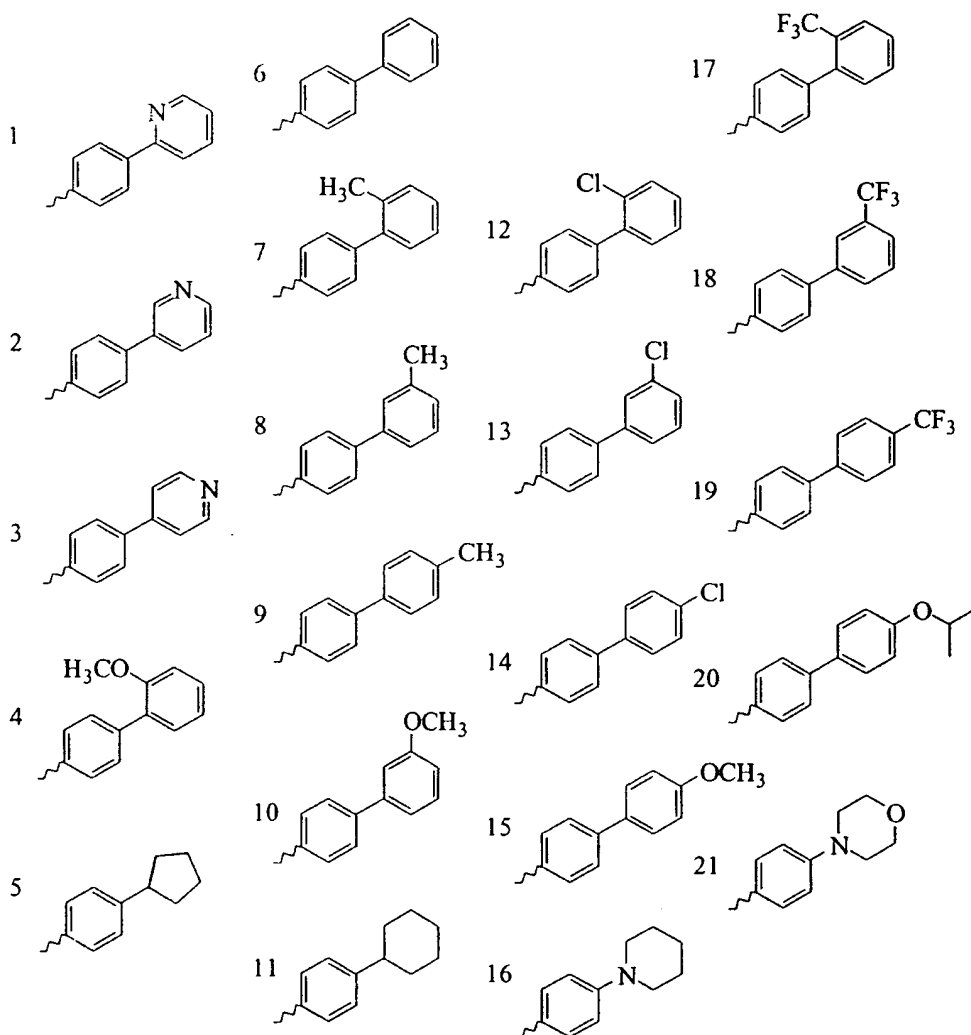
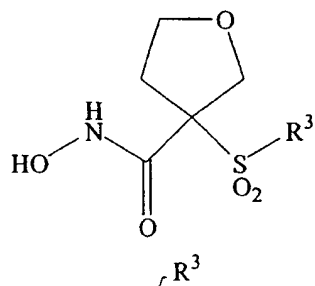


1 	9 	16
2 	10 	17
3 	11 	18
4 	12 	19
5 	13 	20
6 	14 	21
7 	15 	22
8 		

Table 103

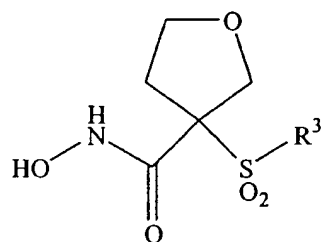
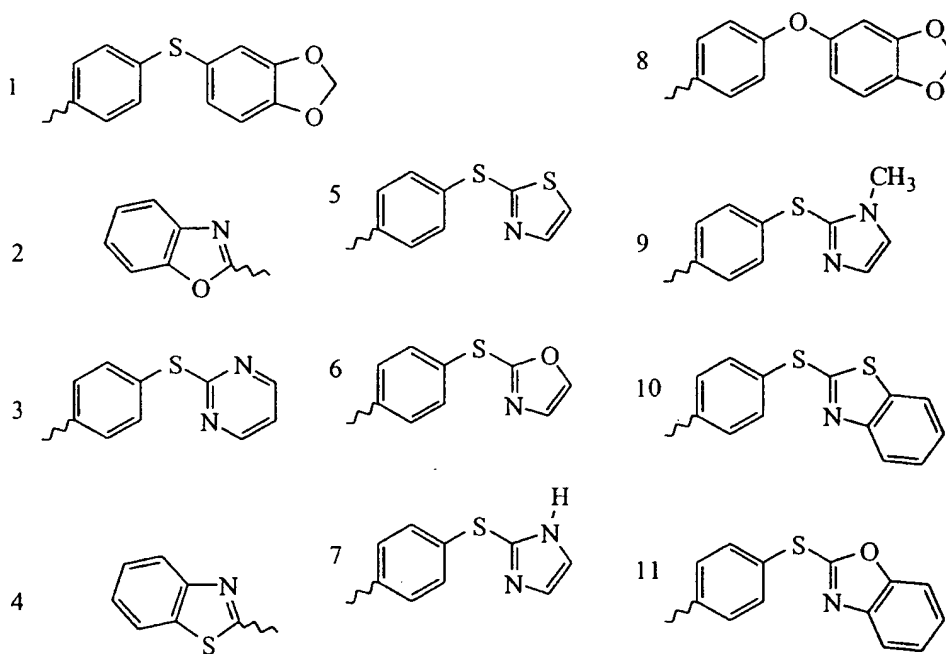
- 233 -

Table 104



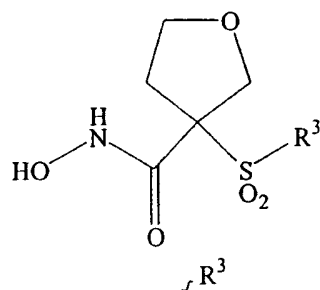
- 234 -

Table 105

 R^3 

- 235 -

Table 106



1 	8 	15
2 	9 	16
3 	10 	17
4 	11 	18
5 	12 	19
6 	13 	20
7 	14 	21

- 236 -

Table 107

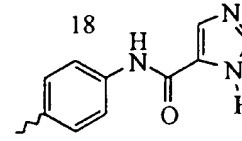
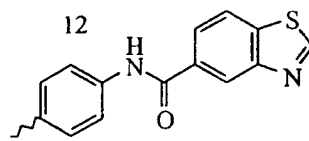
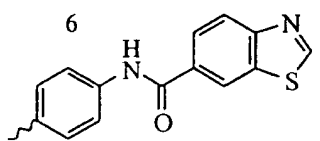
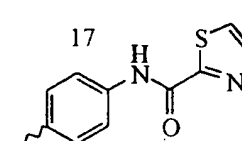
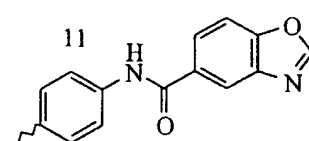
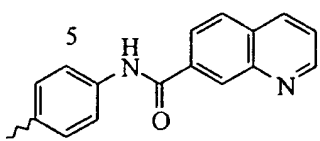
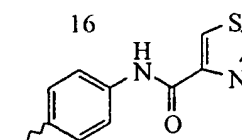
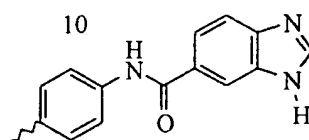
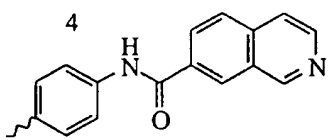
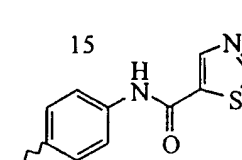
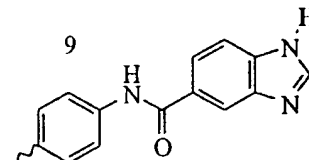
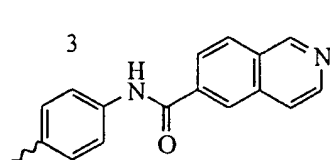
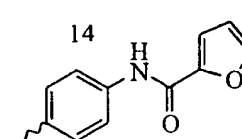
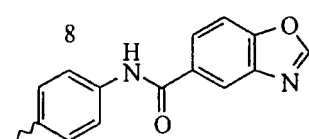
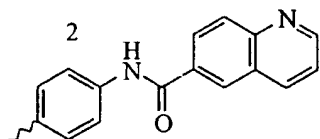
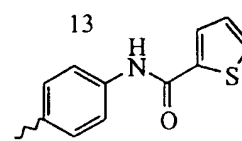
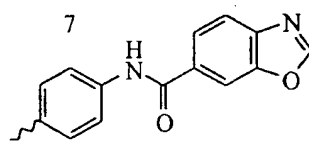
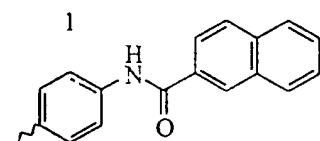
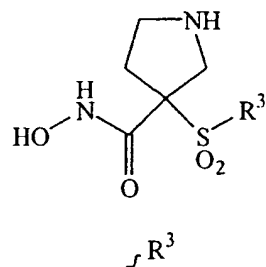
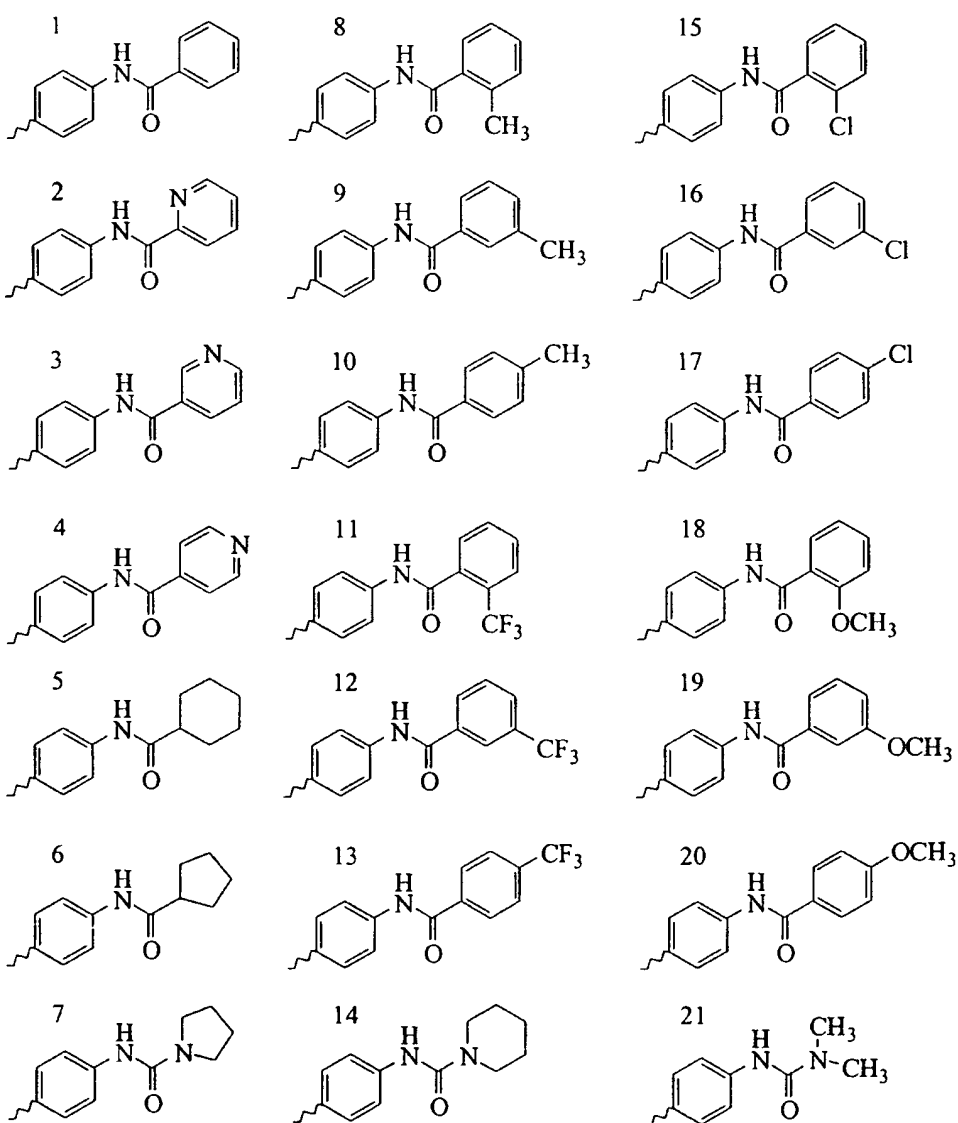
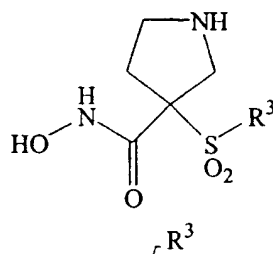
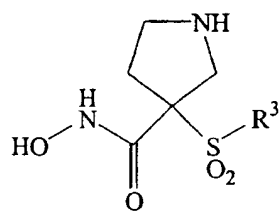
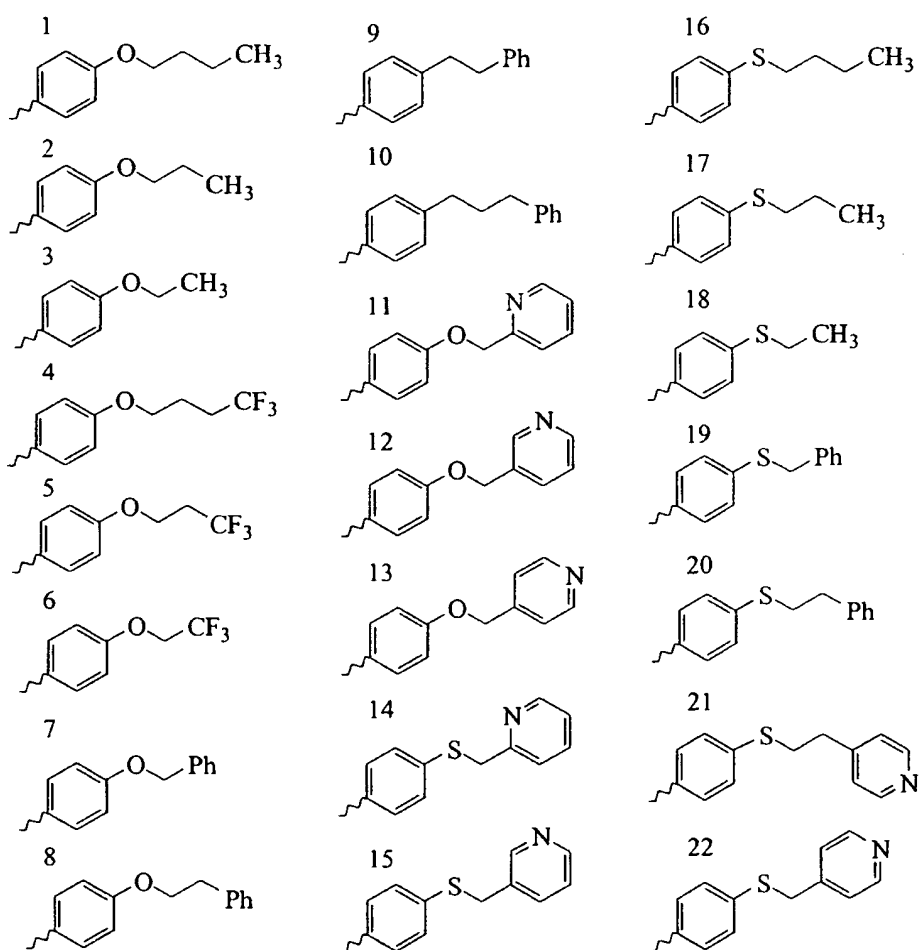


Table 108



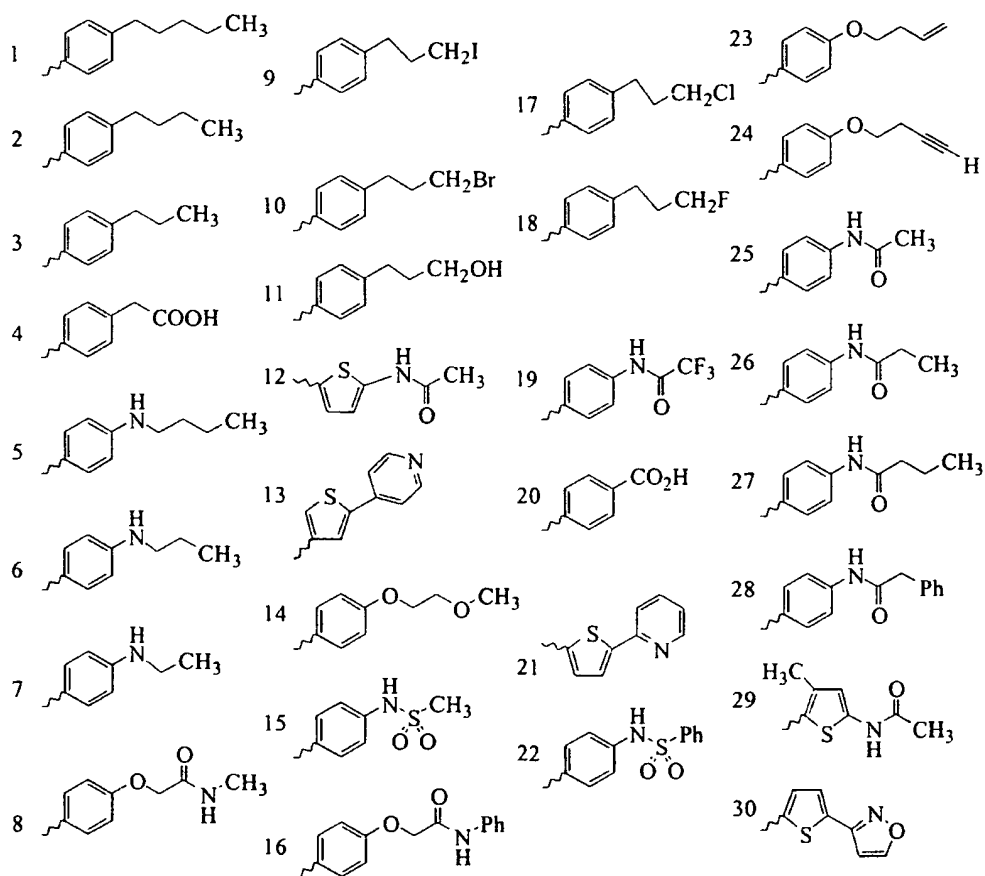
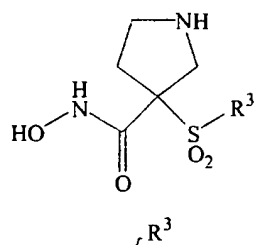
- 238 -

Table 109

 R^3 

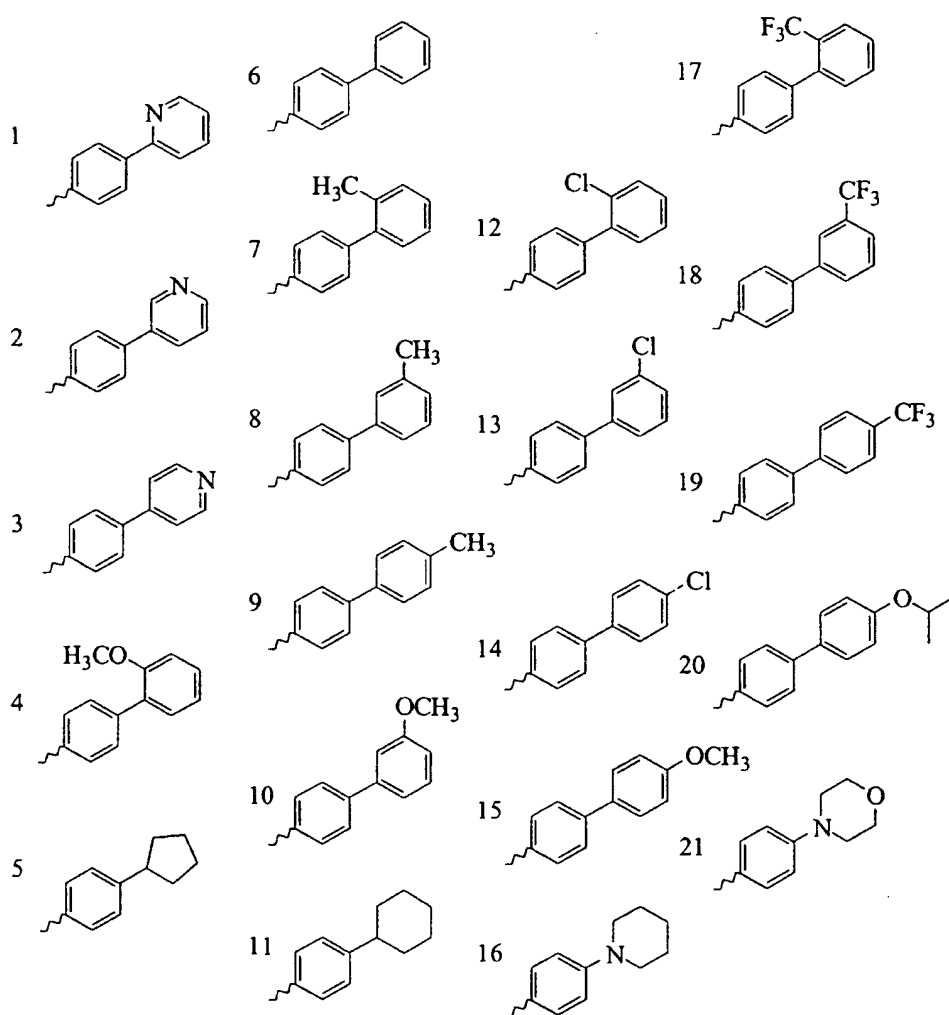
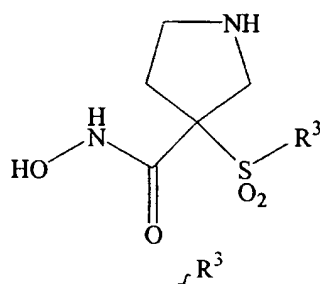
- 239 -

Table 110



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Table 111



- 241 -

Table 112

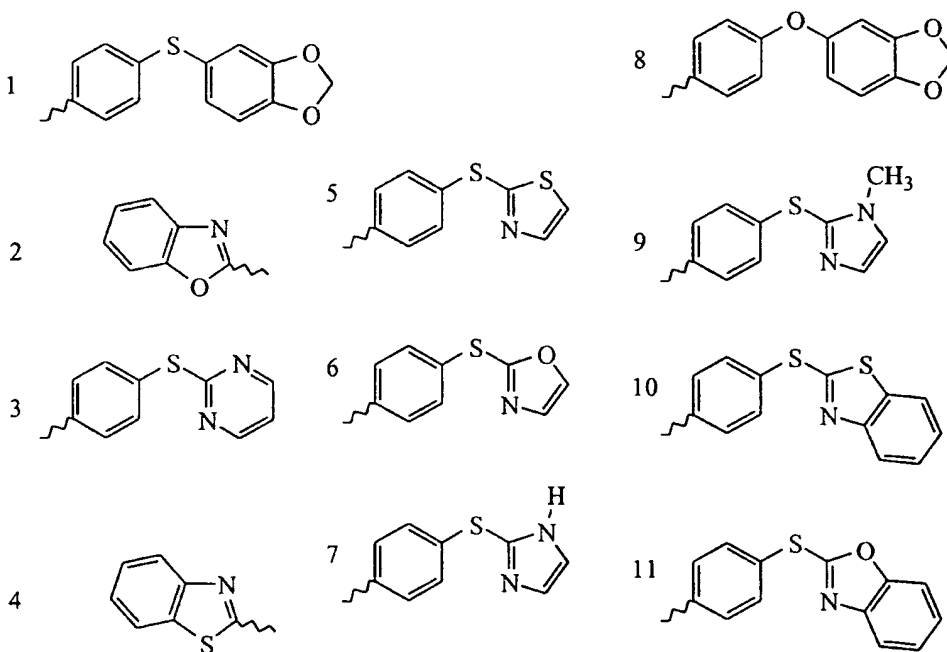
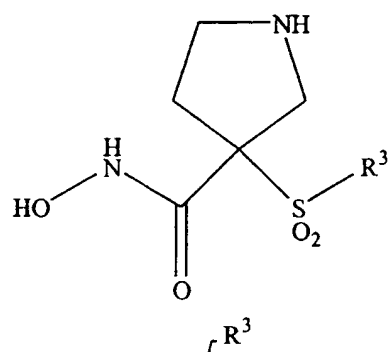
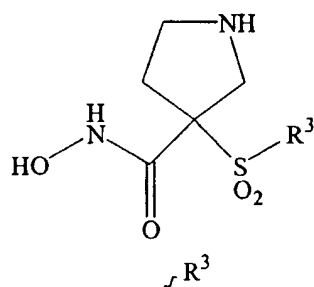


Table 113



1	8	15
2	9	16
3	10	17
4	11	18
5	12	19
6	13	20
7	14	21

- 243 -

Table 114

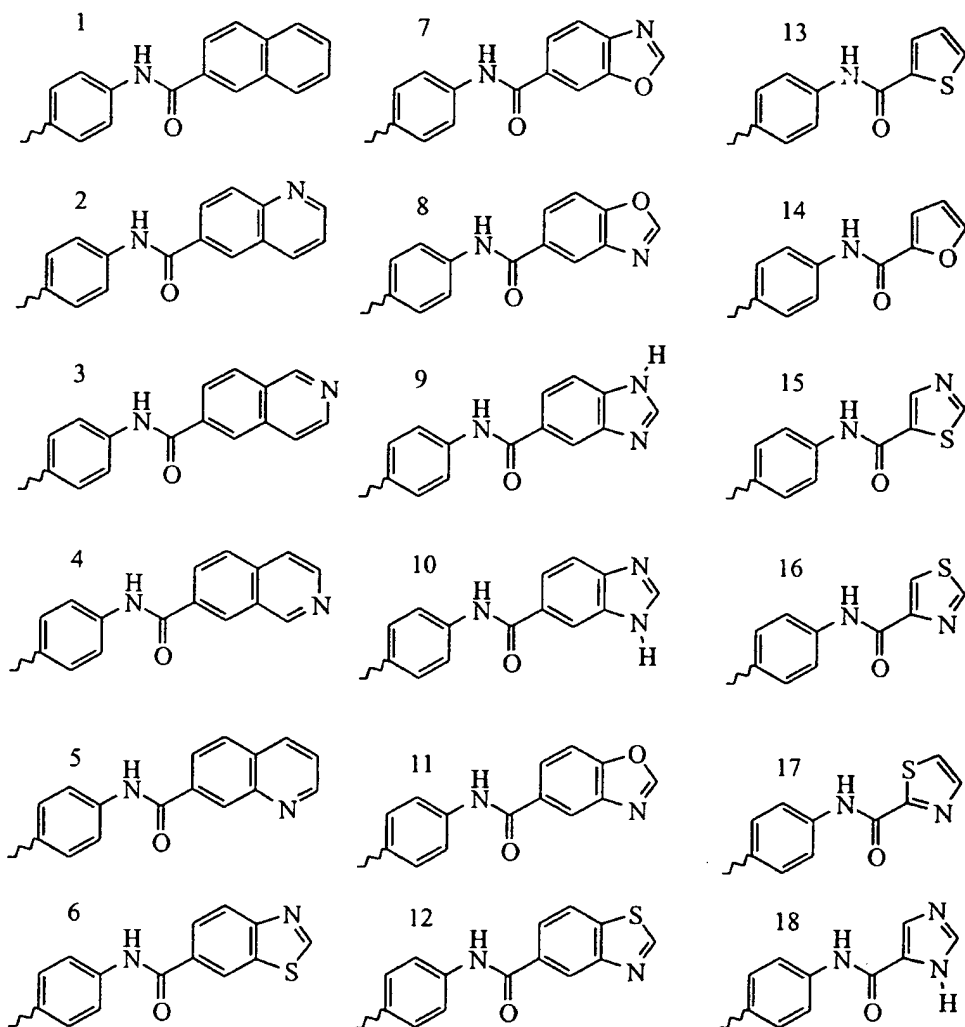
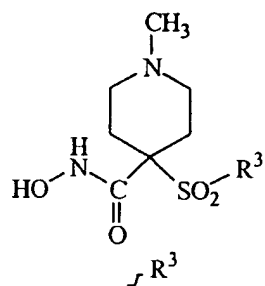
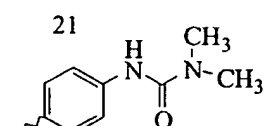
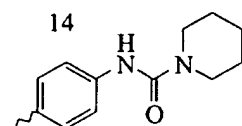
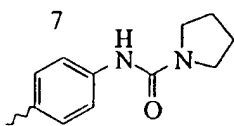
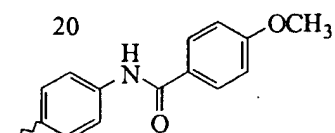
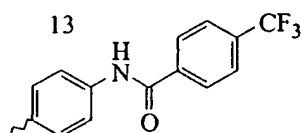
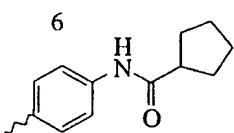
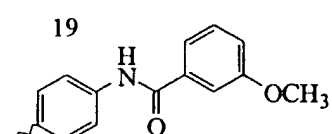
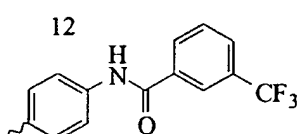
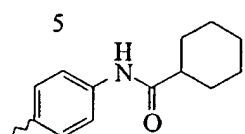
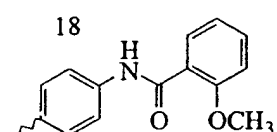
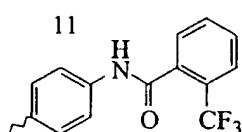
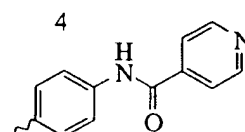
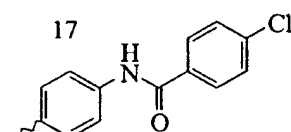
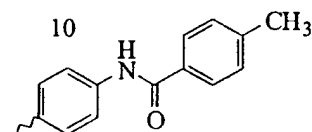
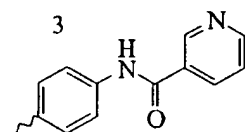
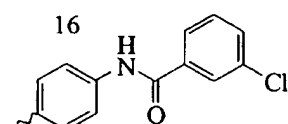
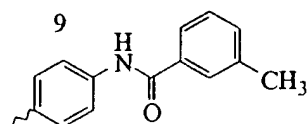
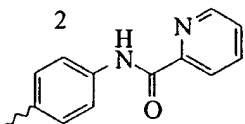
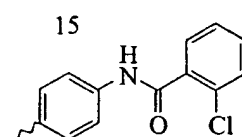
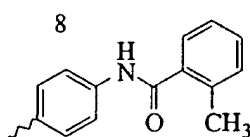
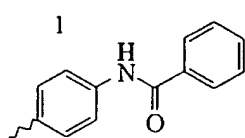
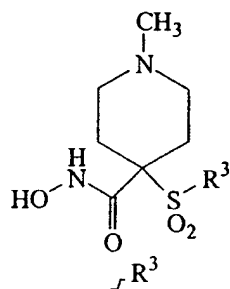
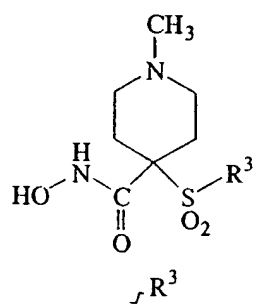


Table 115



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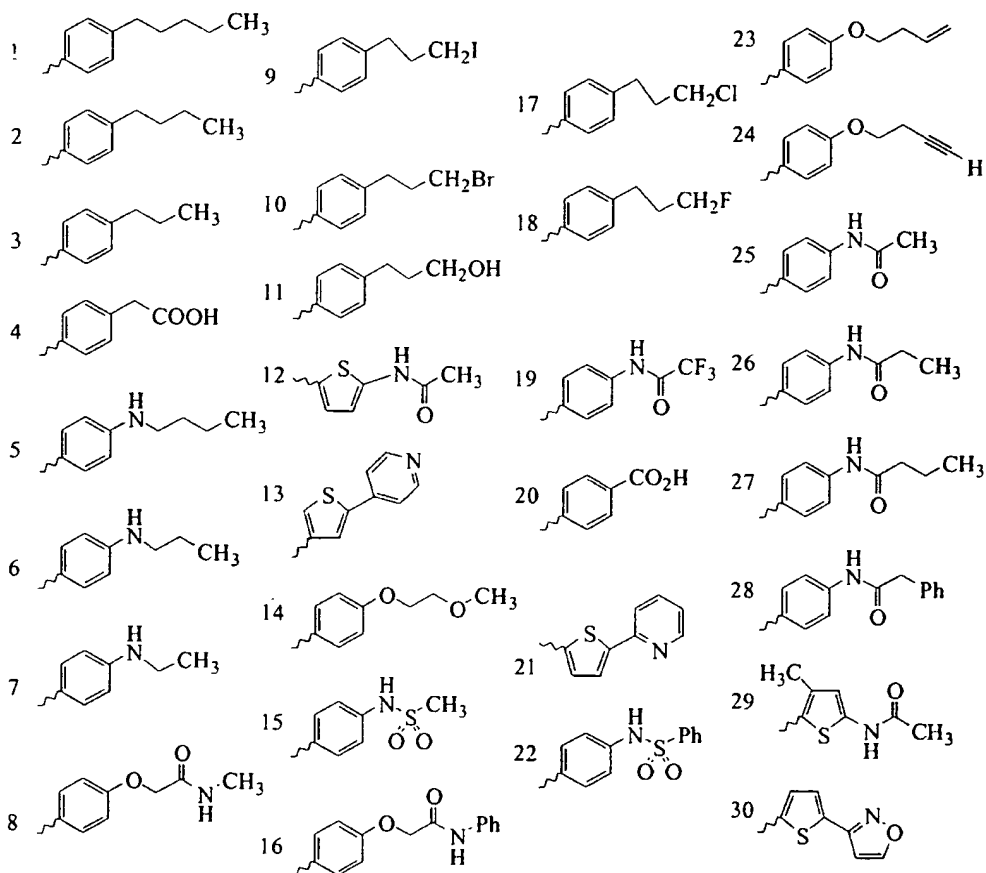
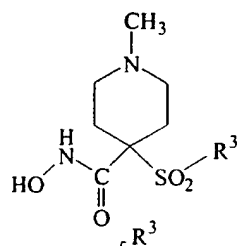
Table 116



1 	9 	16
2 	10 	17
3 	11 	18
4 	12 	19
5 	13 	20
6 	14 	21
7 	15 	22
8 		

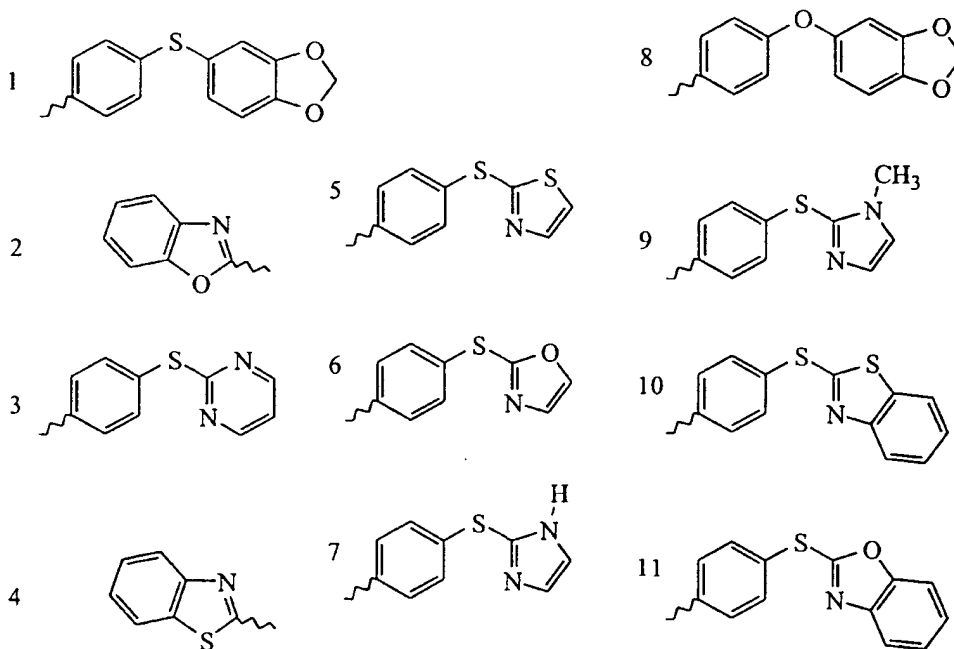
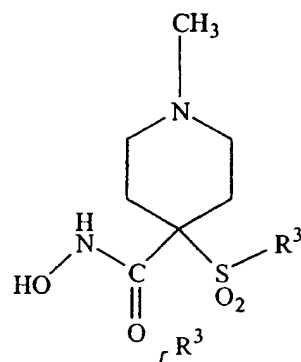
- 246 -

Table 117



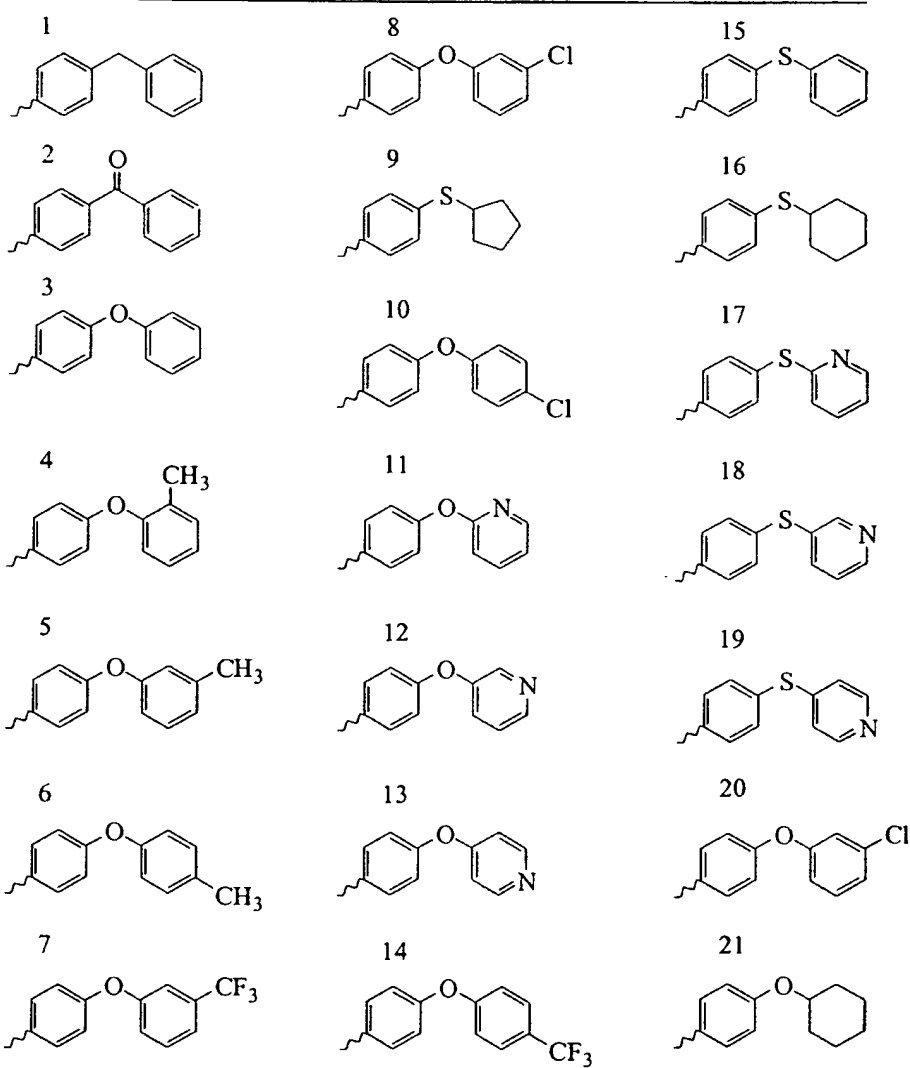
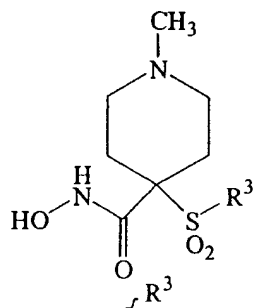
-247-

Table 118



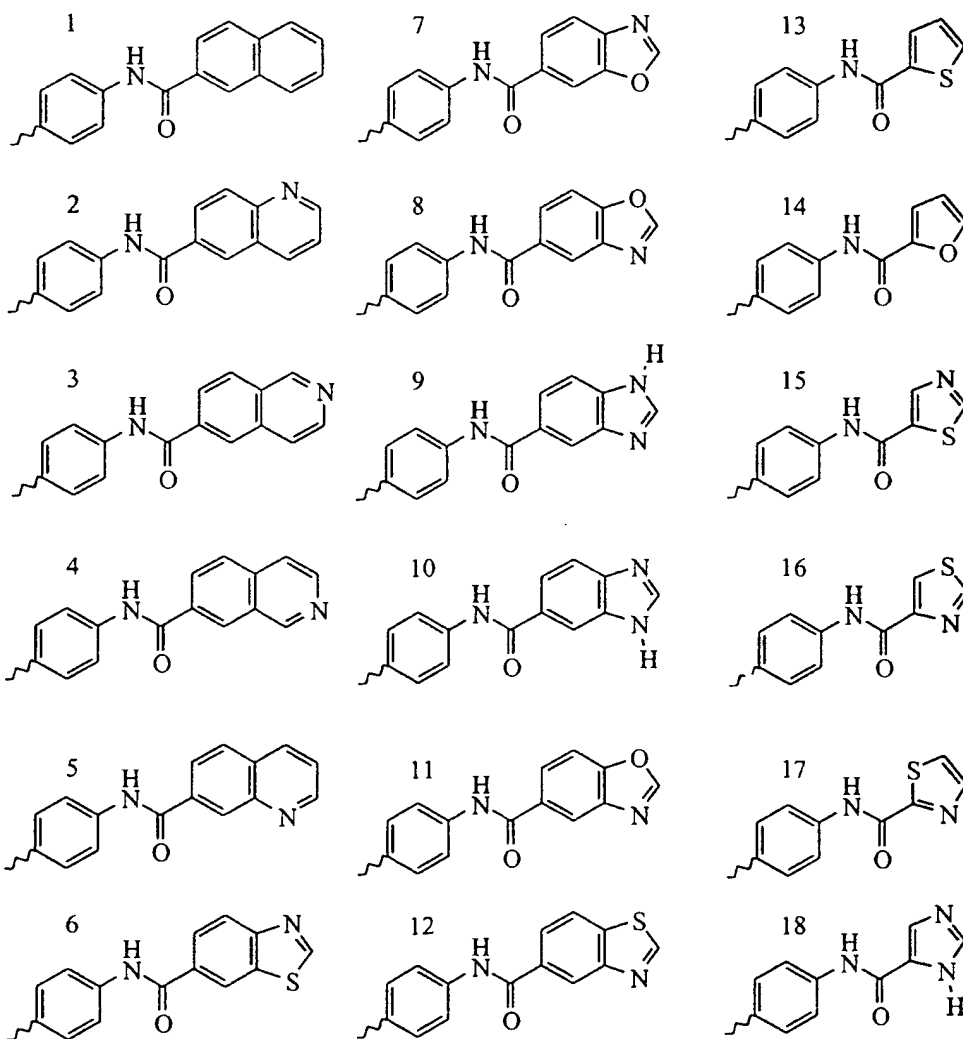
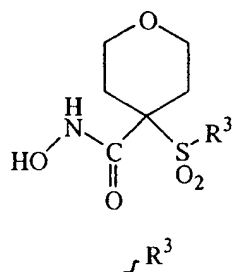
-248-

Table 119



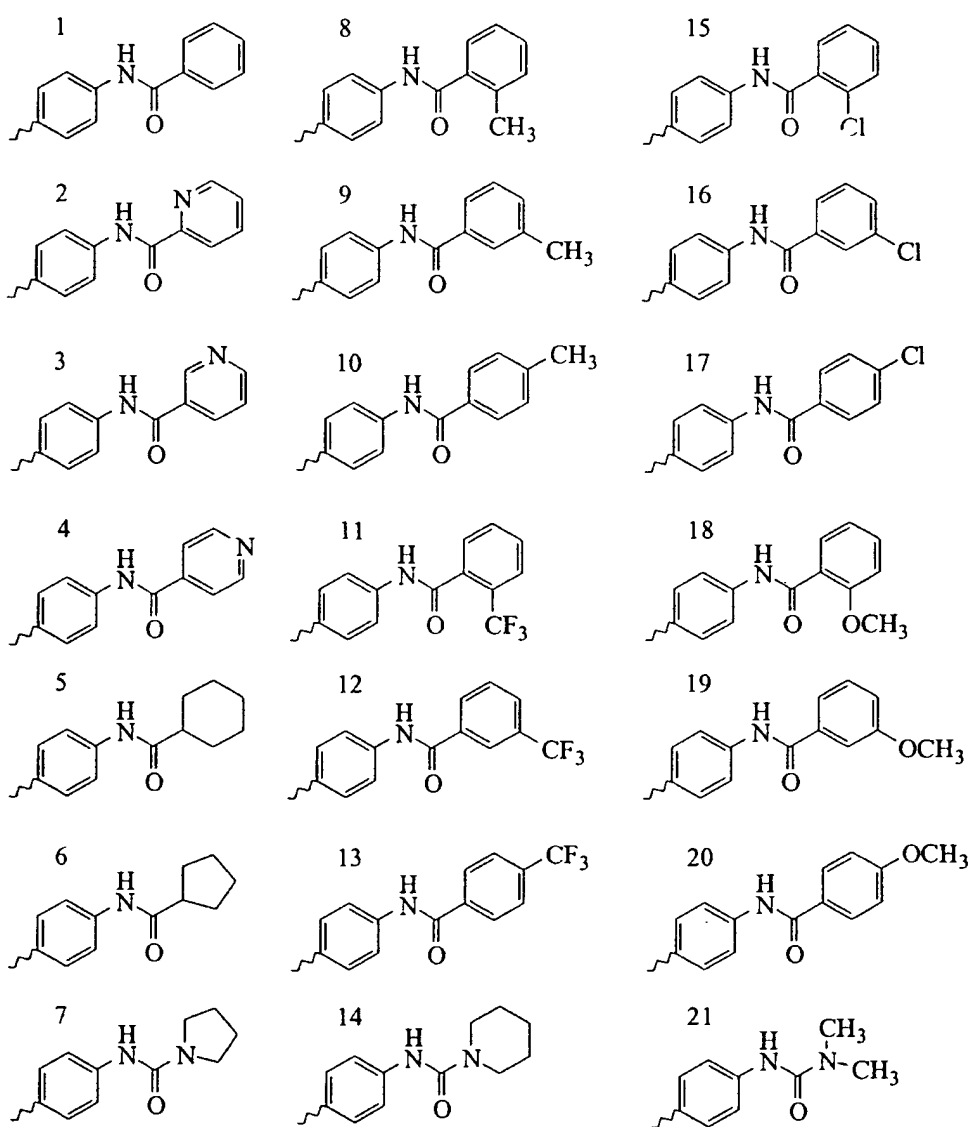
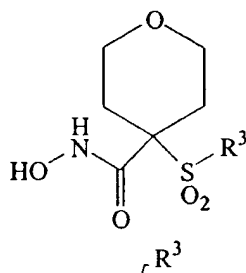
-249-

Table 120



- 250 -

Table 121



- 251 -

Table 122

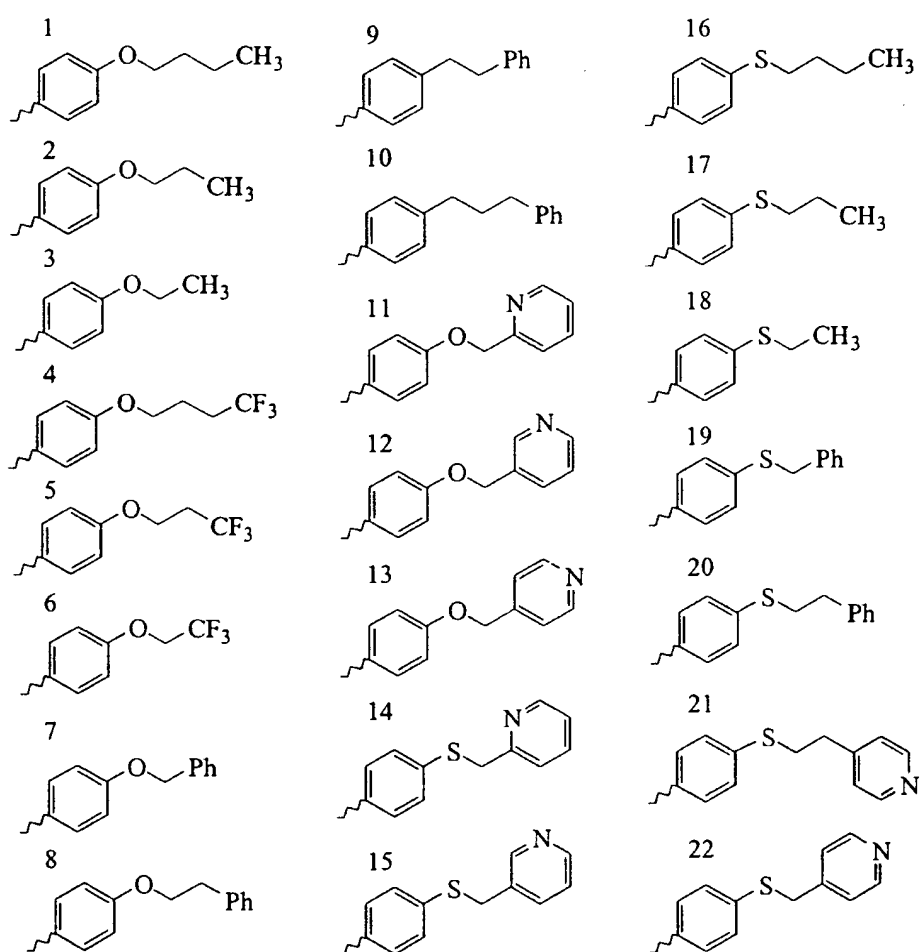
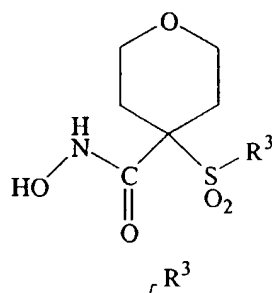
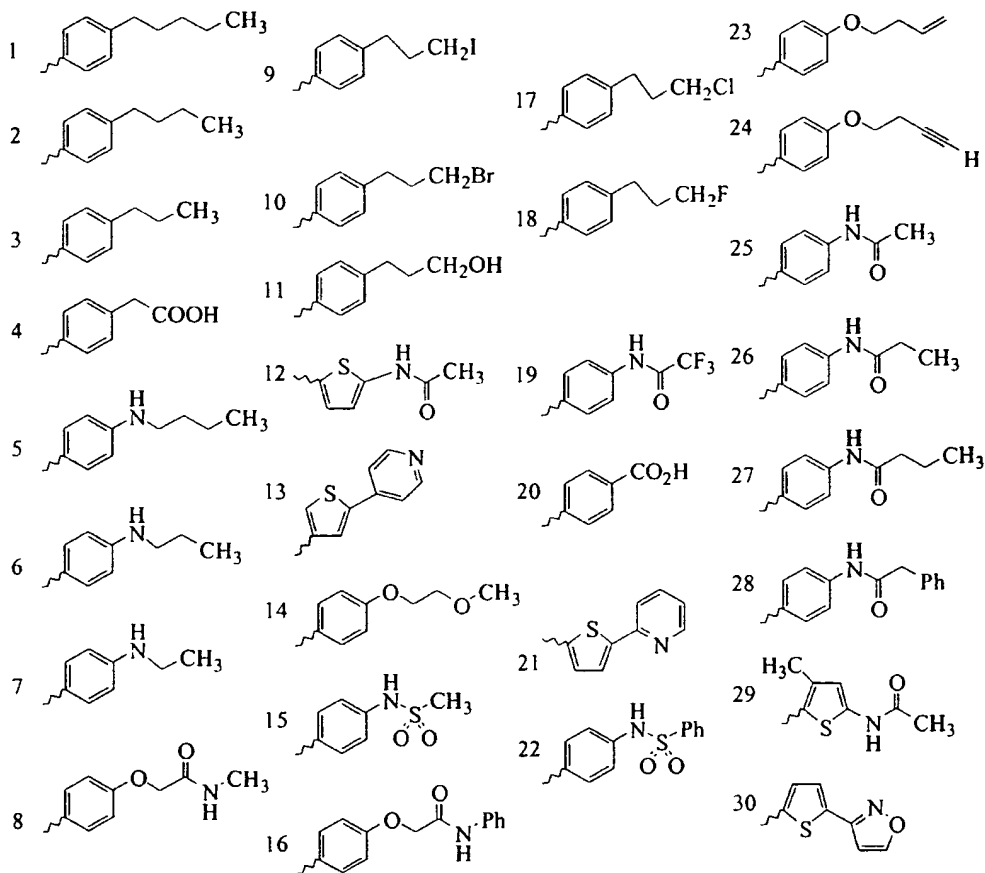
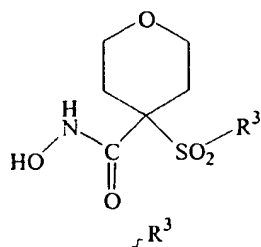
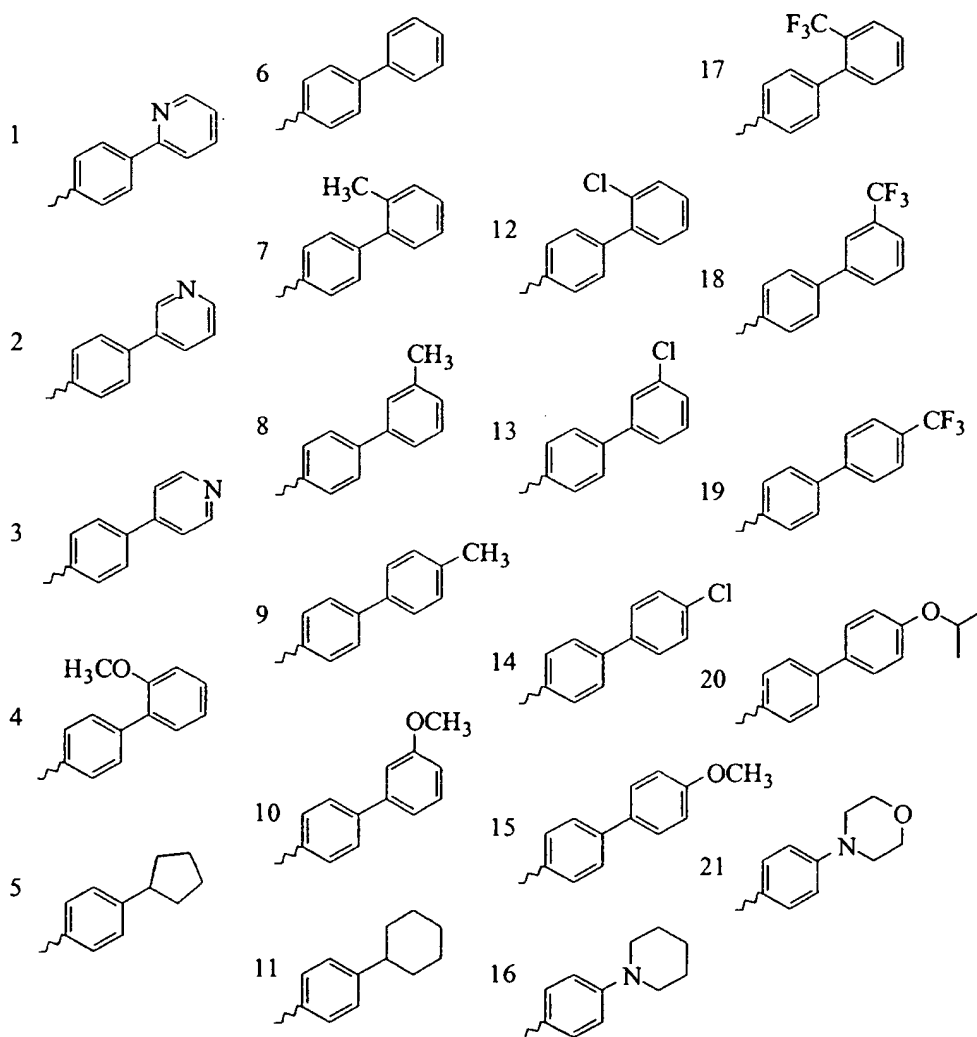
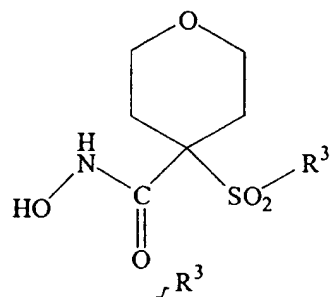


Table 123

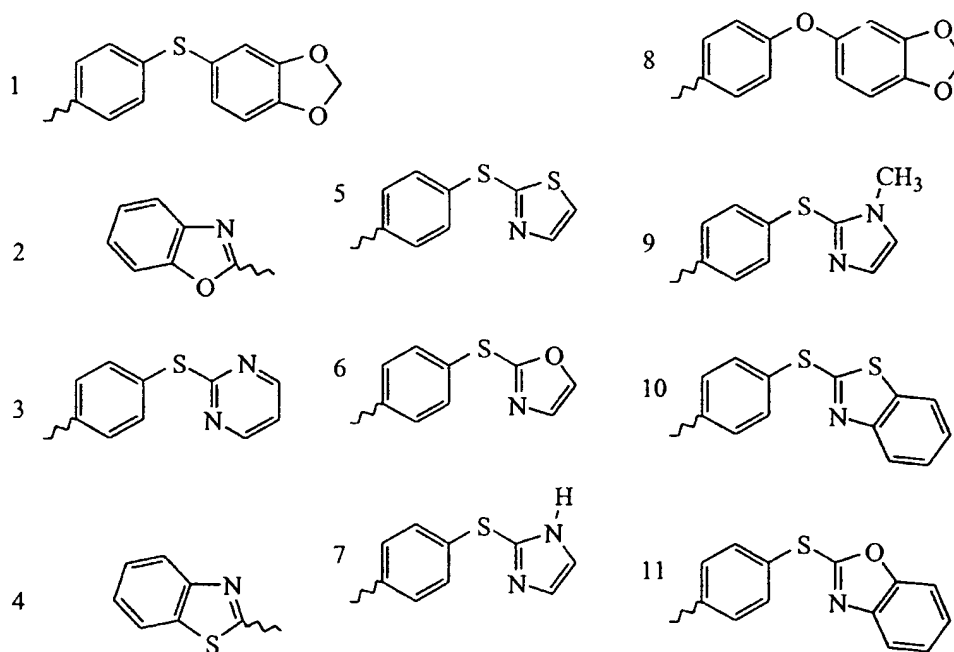
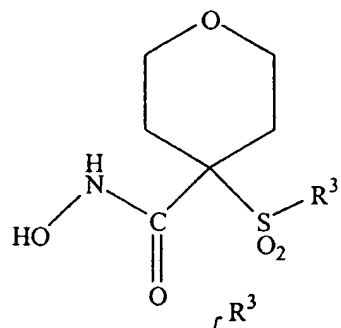
- 253 -

Table 124



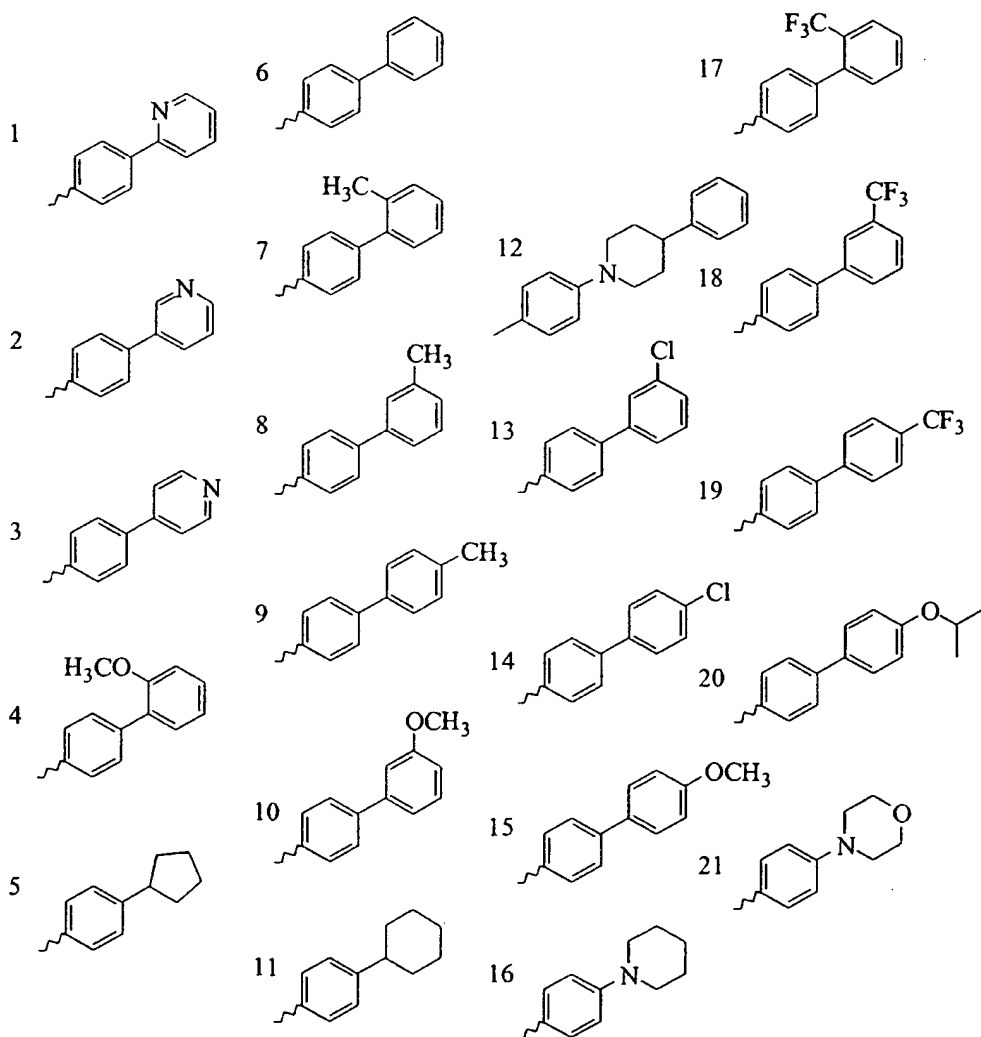
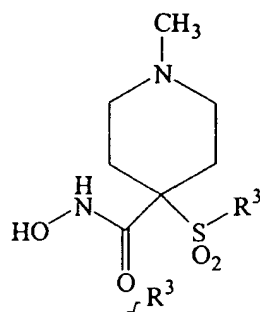
-254-

Table 125



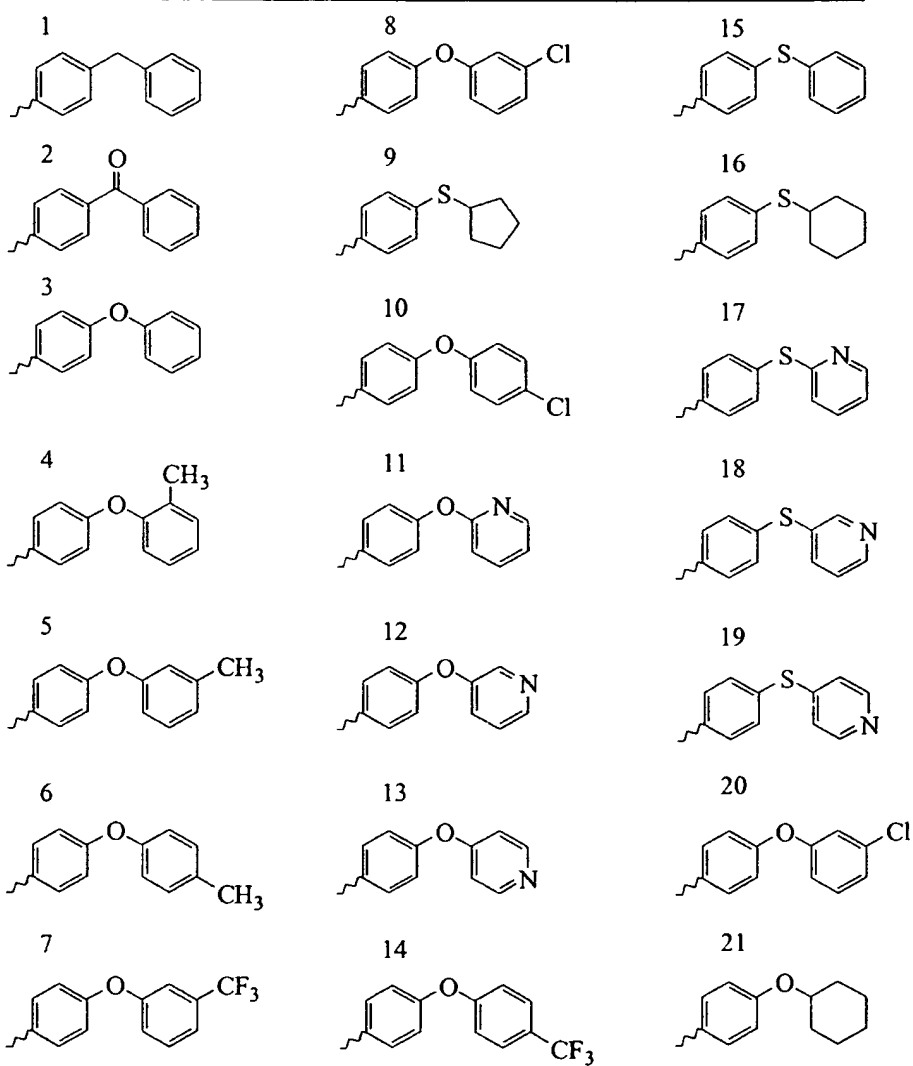
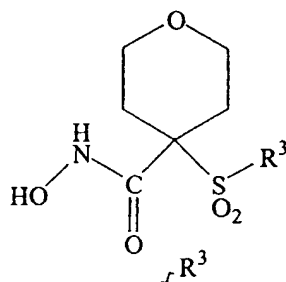
-255-

Table 126



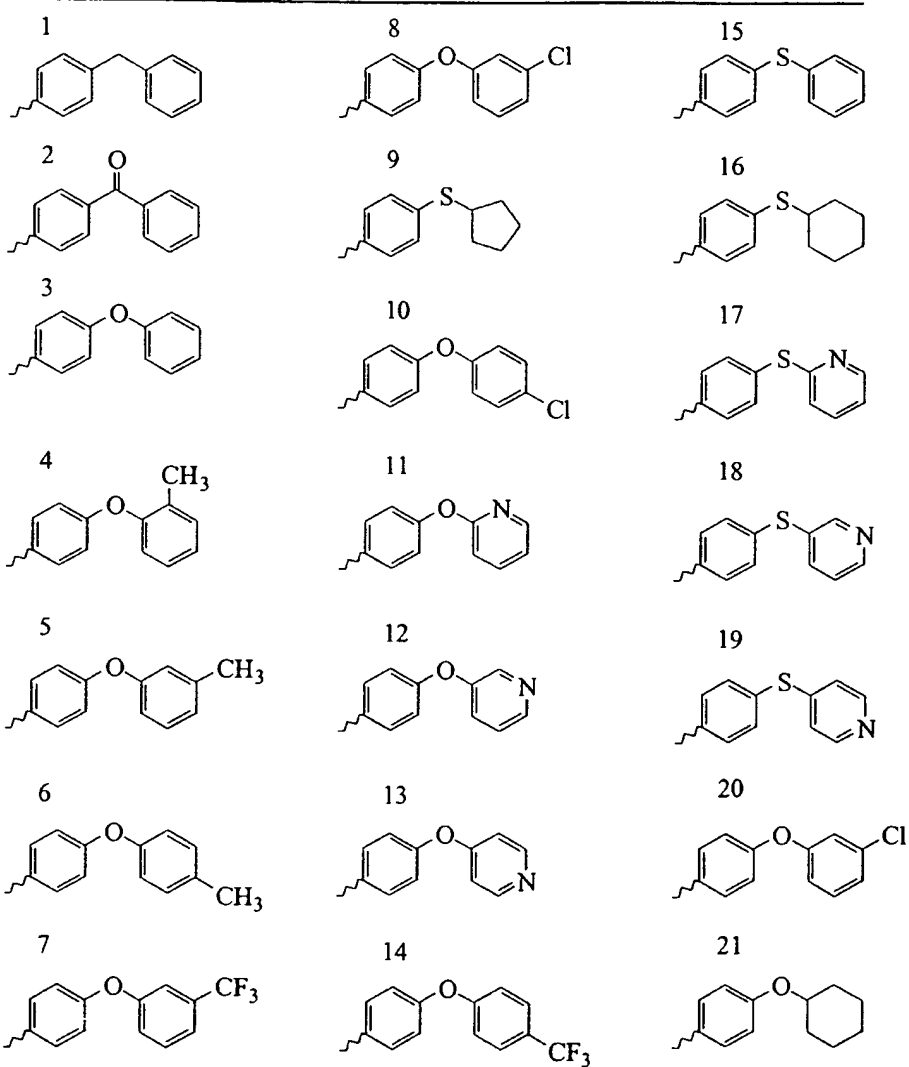
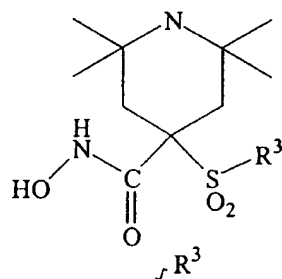
-256-

Table 127



-257-

Table 128



- 258 -

Table 129

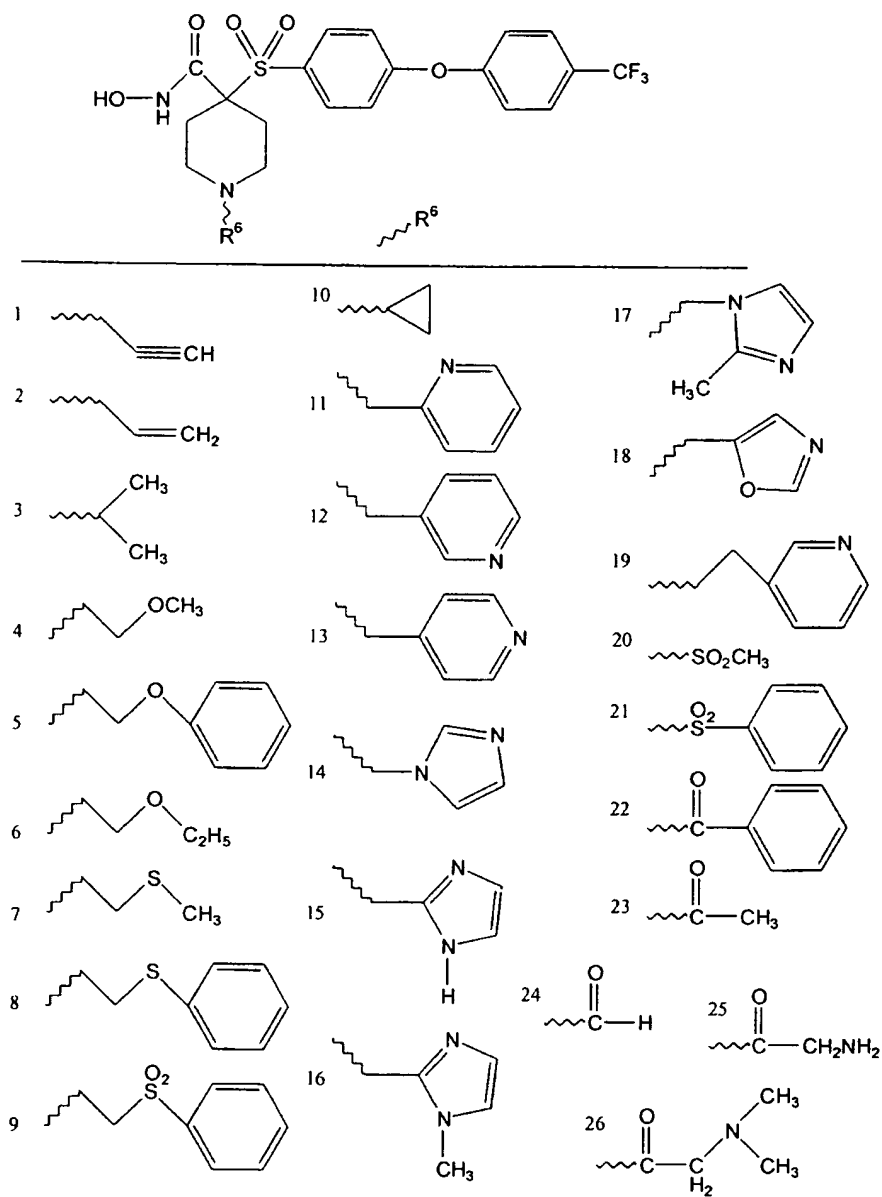
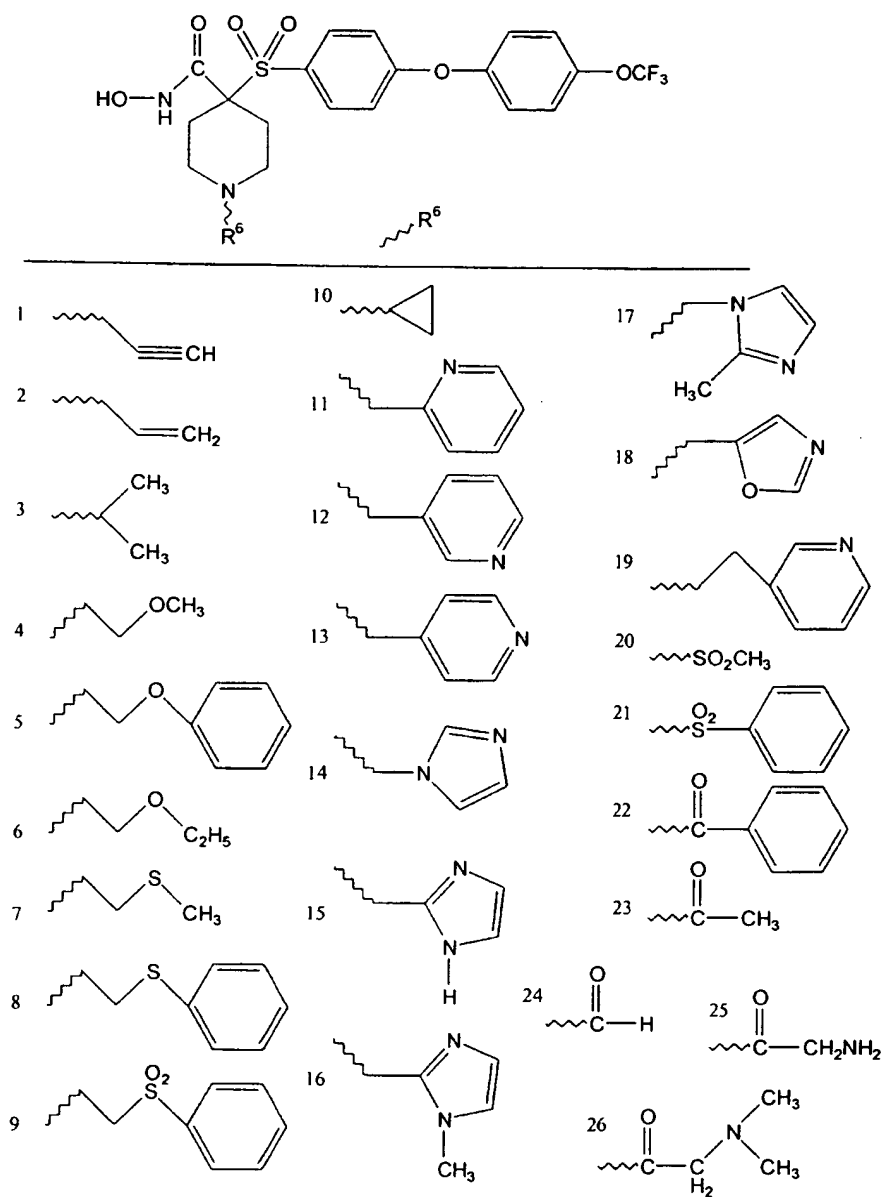
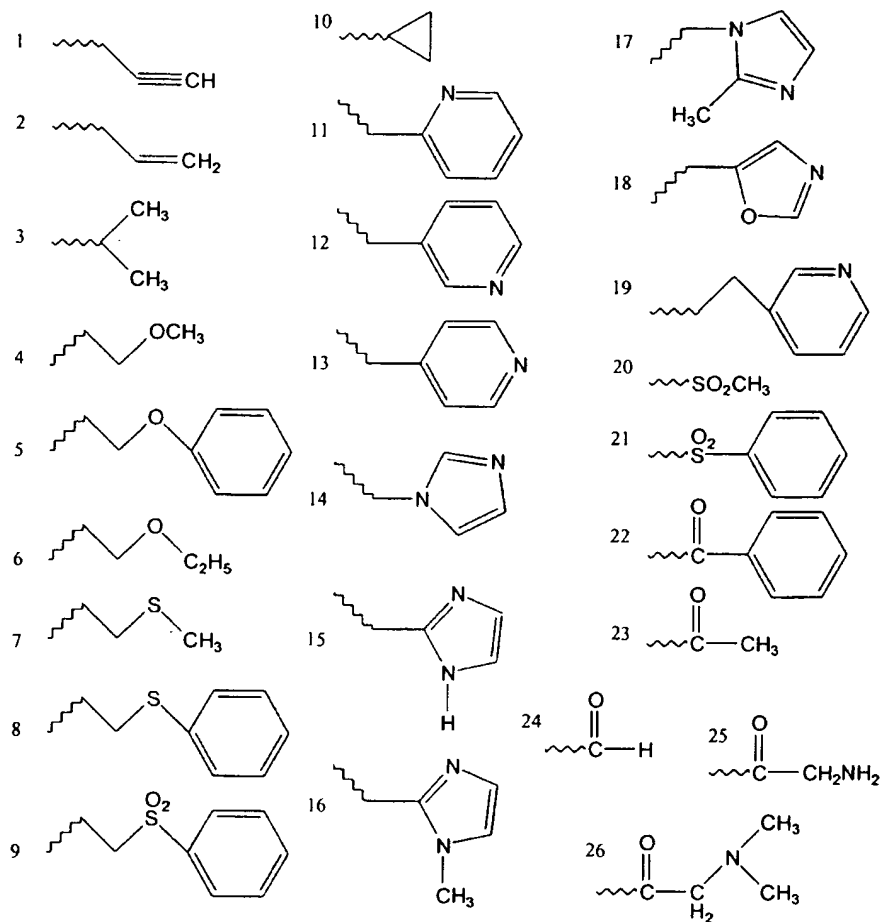
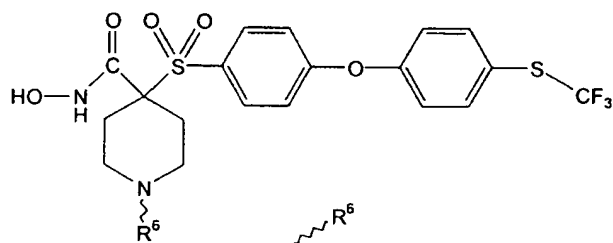


Table 130



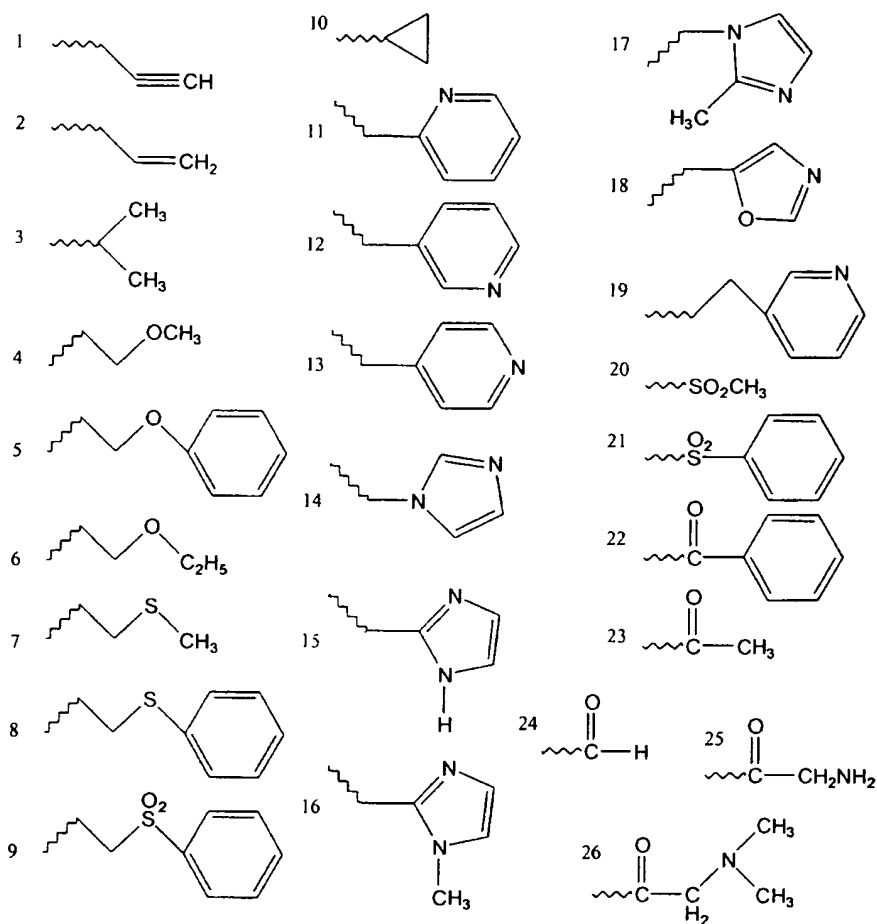
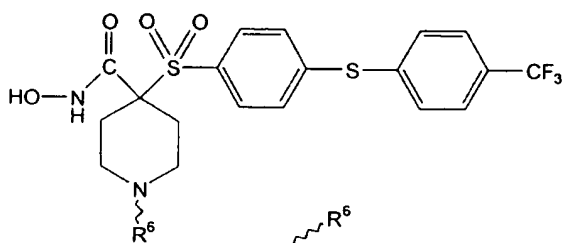
-260-

Table 131



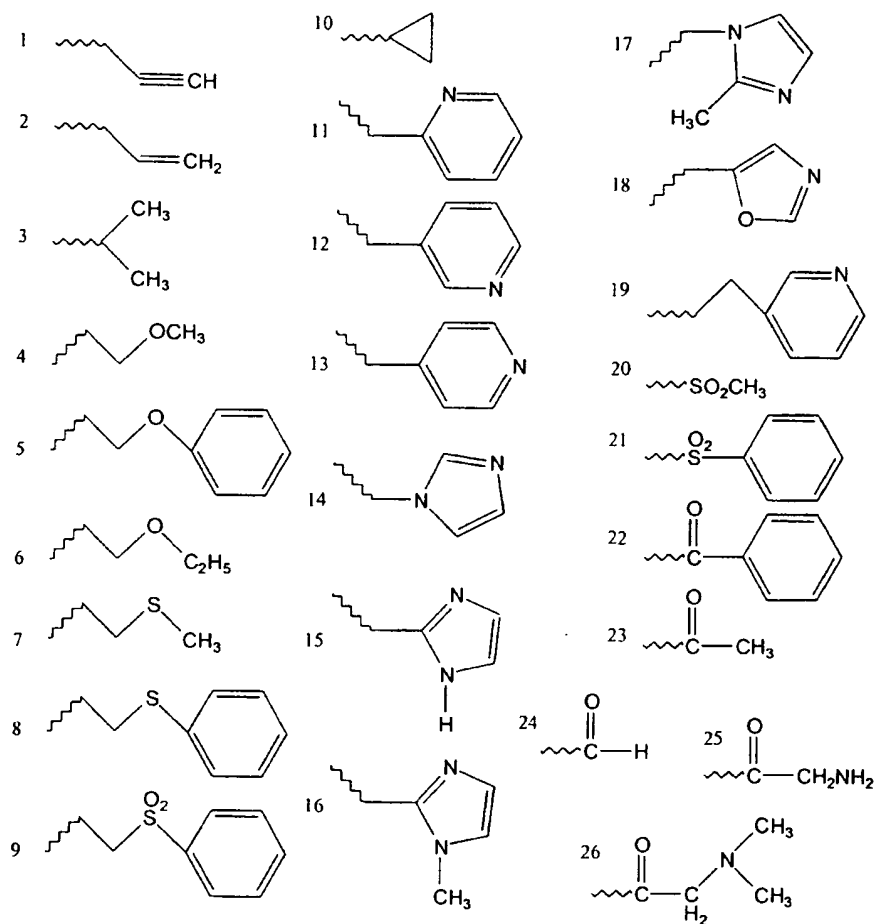
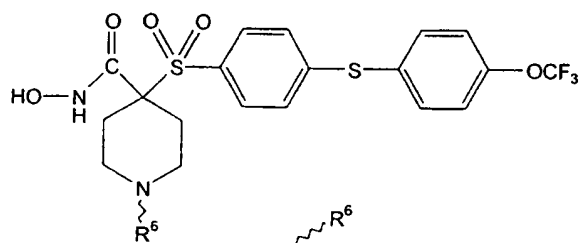
-261-

Table 132



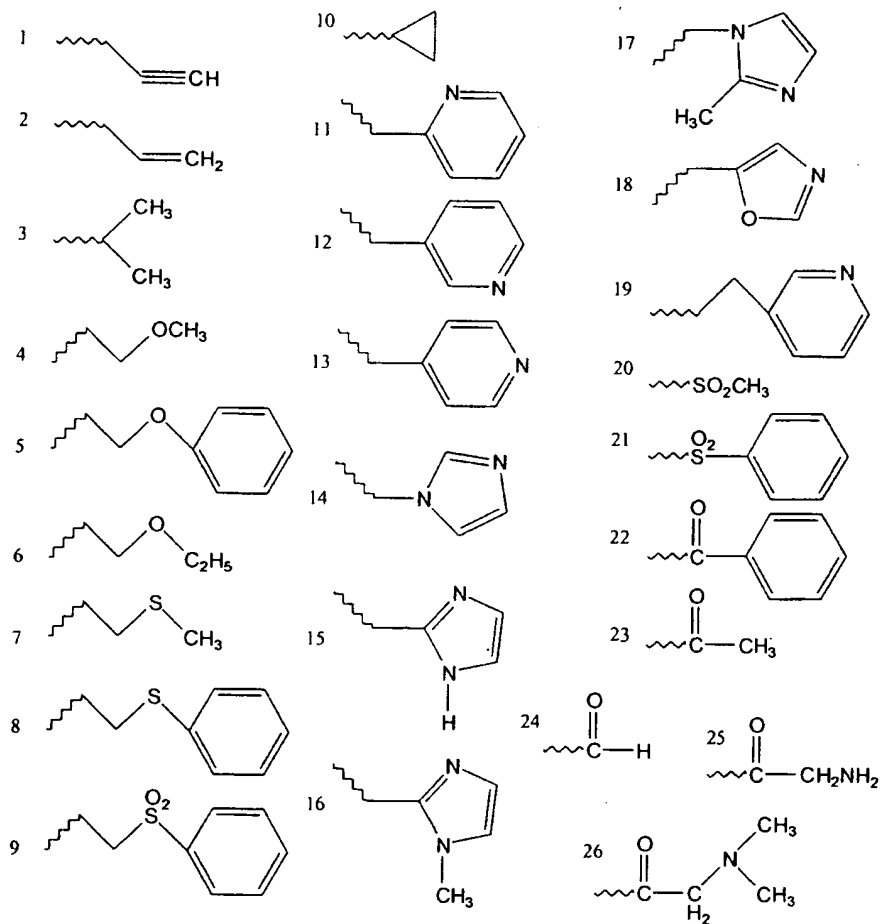
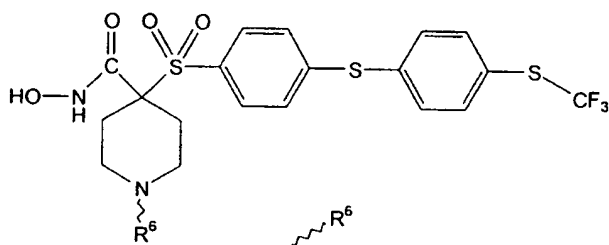
- 262 -

Table 133



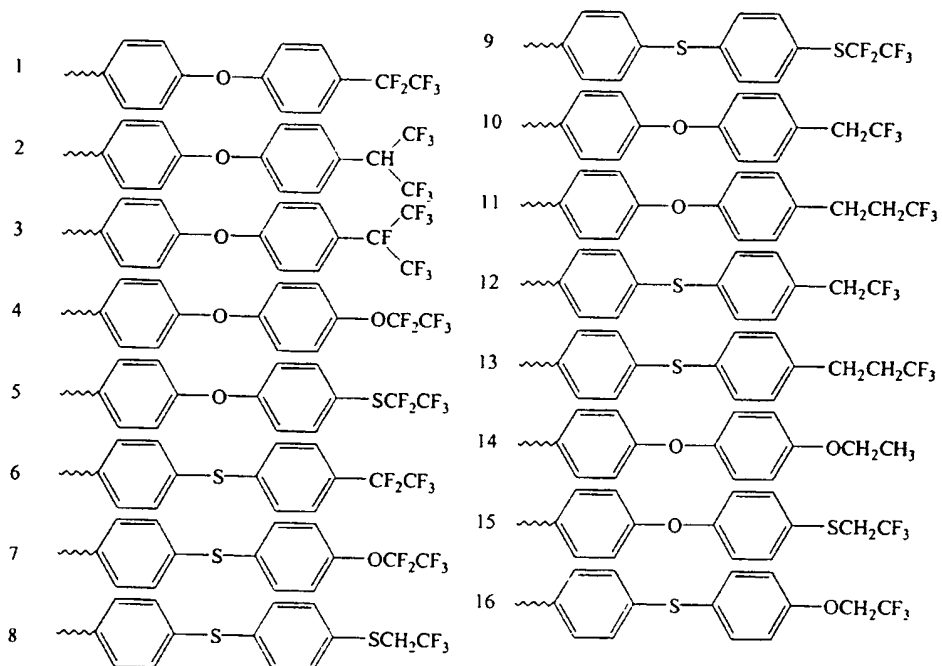
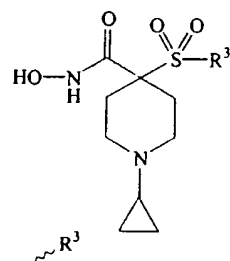
- 263 -

Table 134



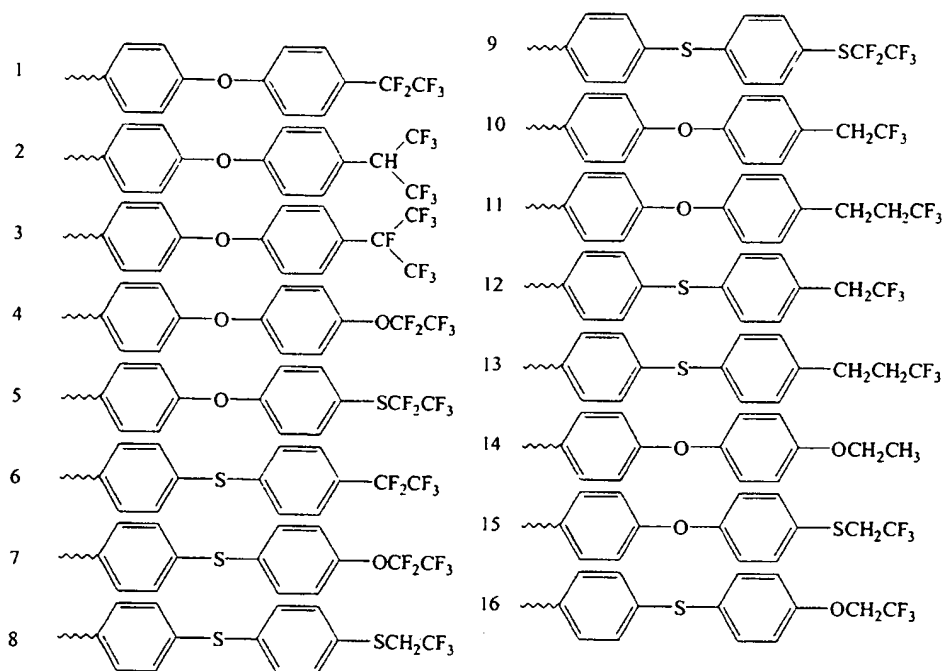
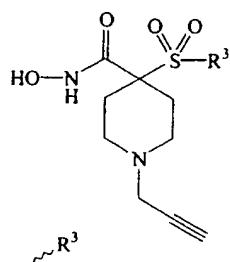
- 264 -

Table 135



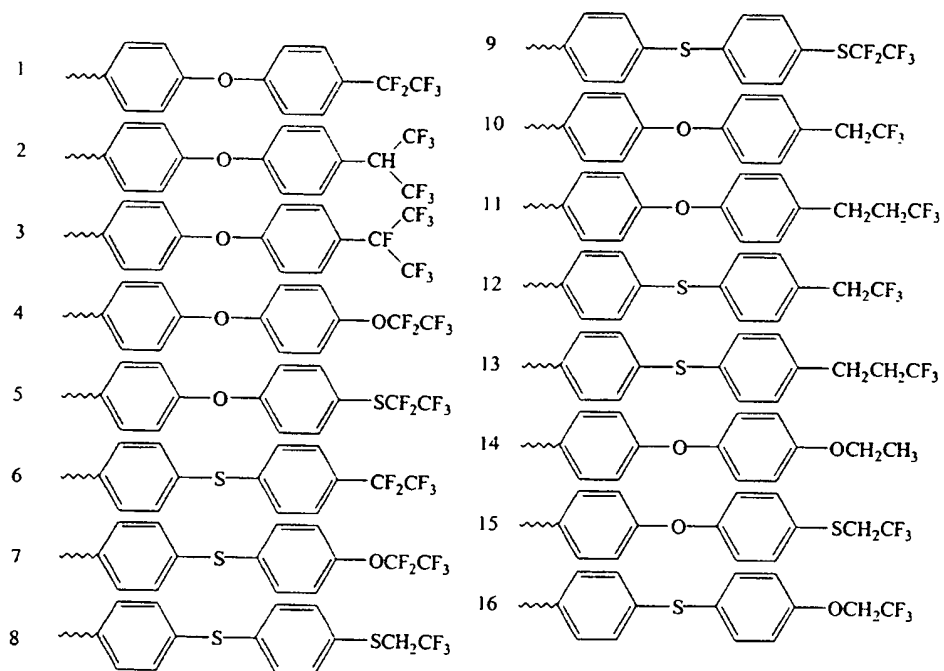
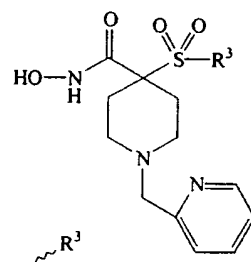
-265-

Table 136



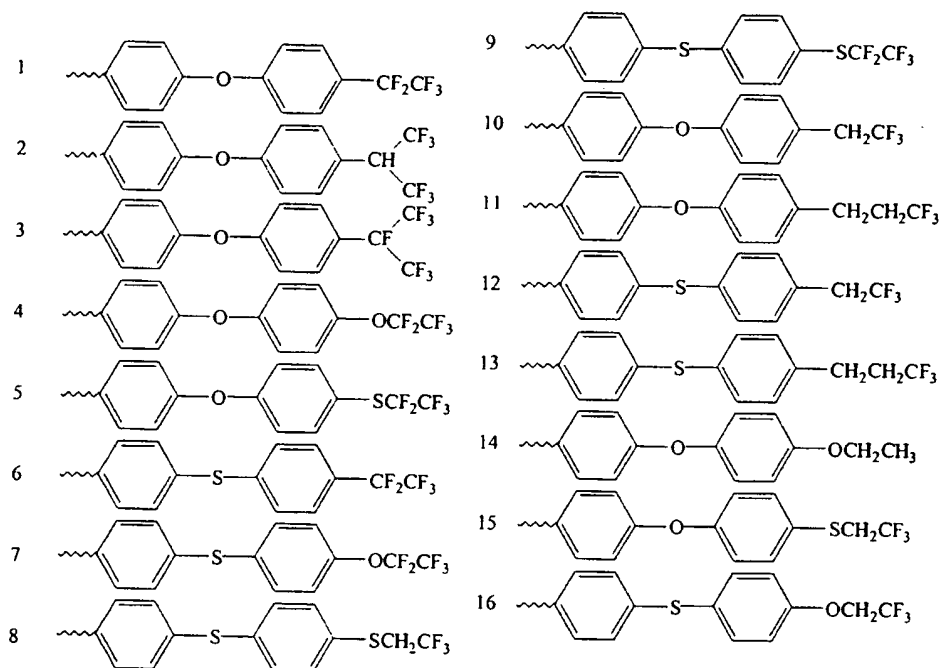
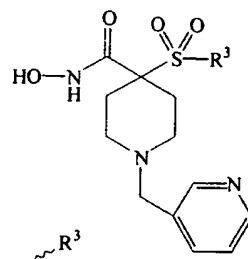
- 266 -

Table 137



- 267 -

Table 138



- 268 -

Table 139

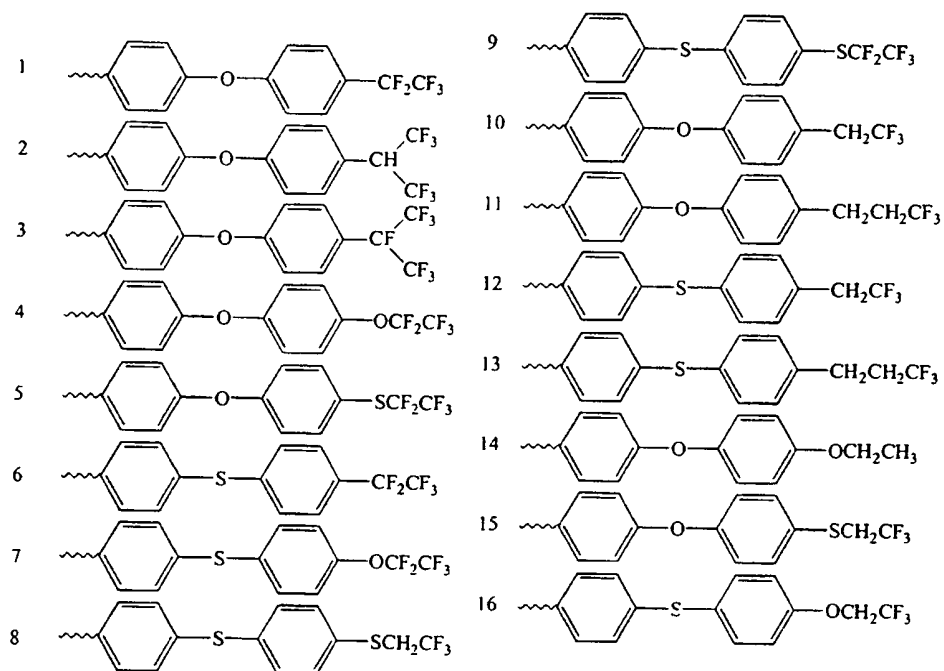
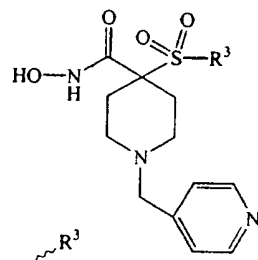
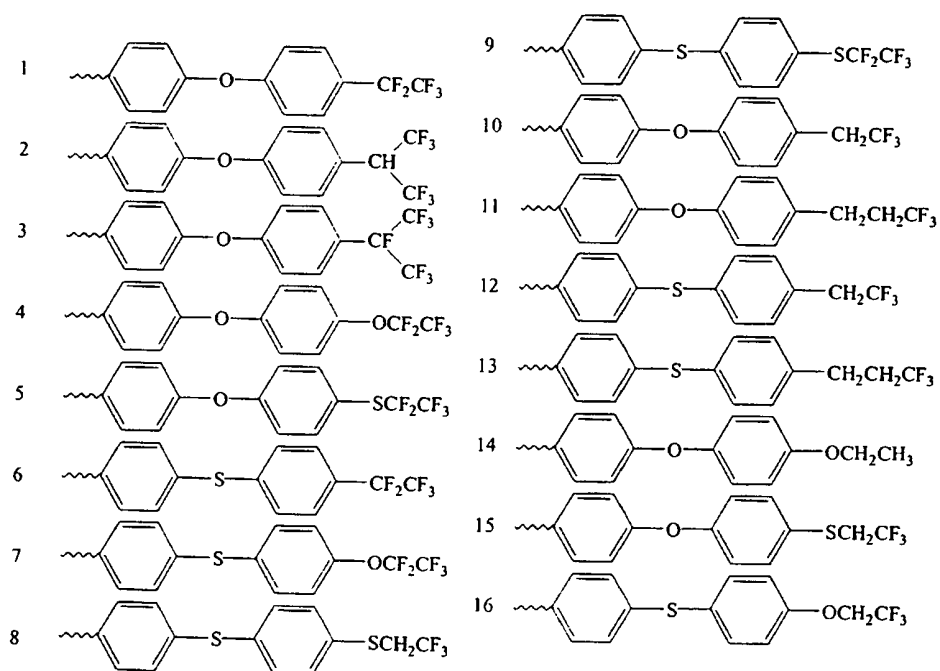
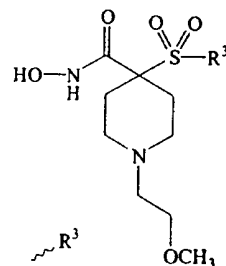
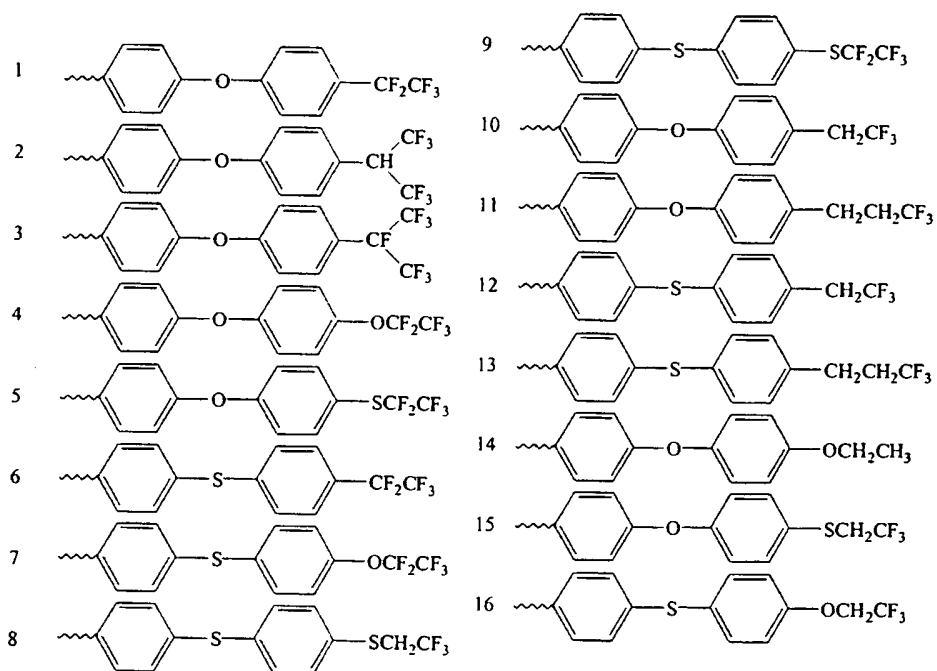
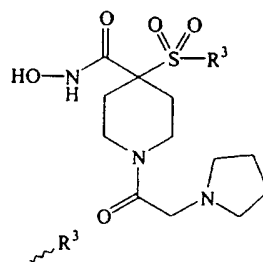


Table 140



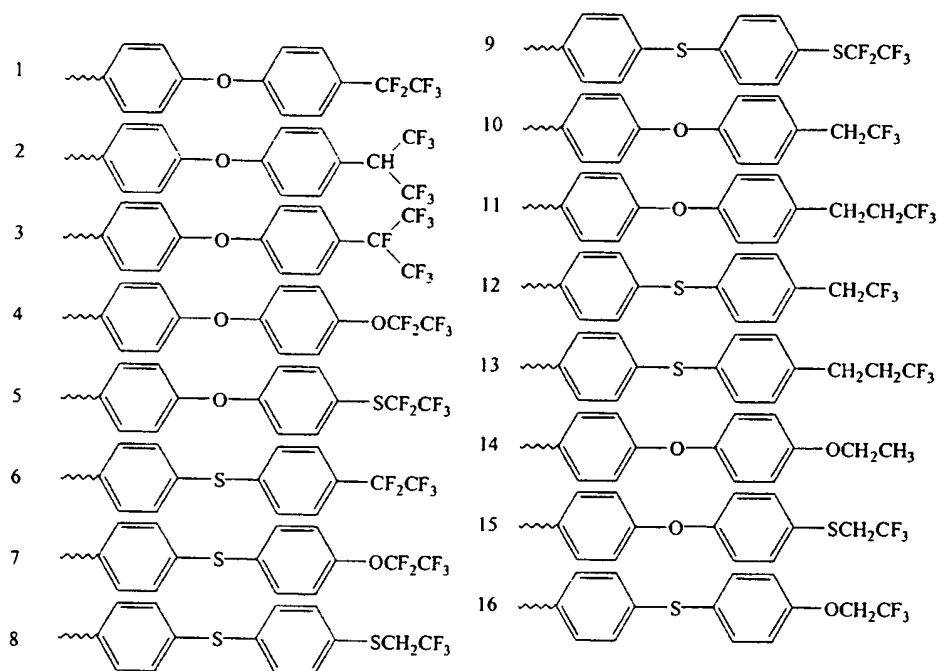
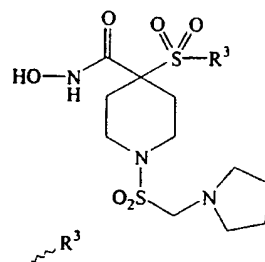
- 270 -

Table 141



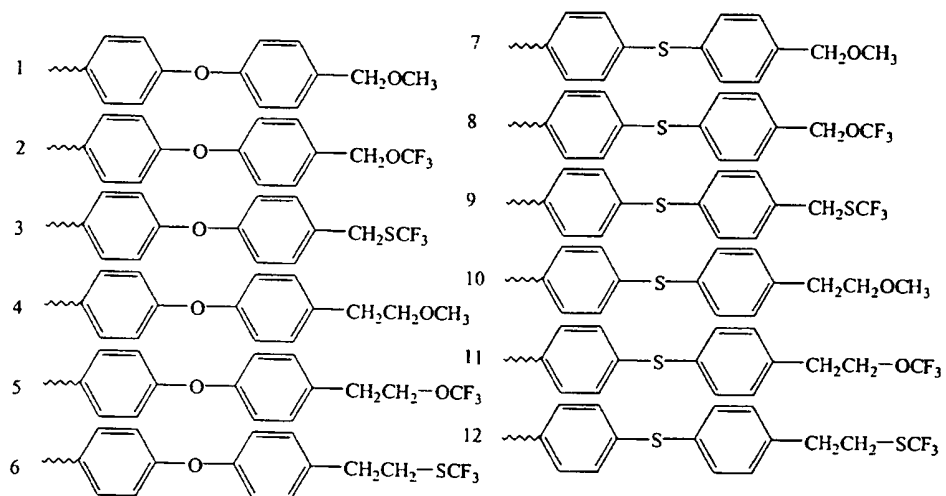
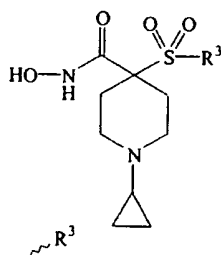
- 271 -

Table 142



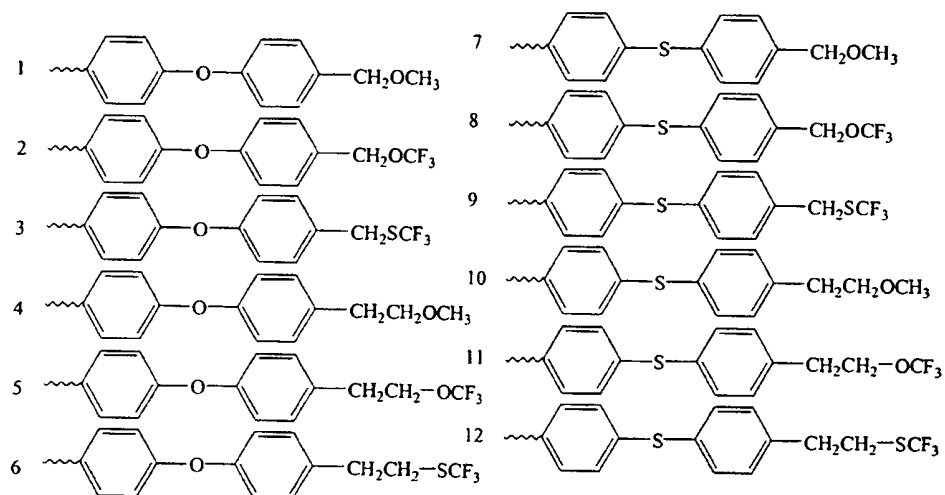
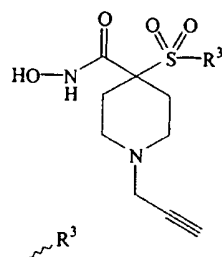
- 272 -

Table 143



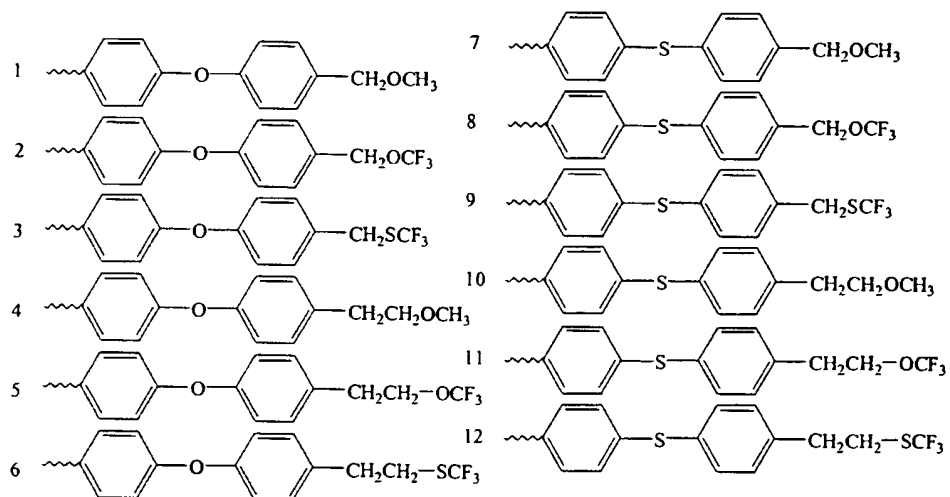
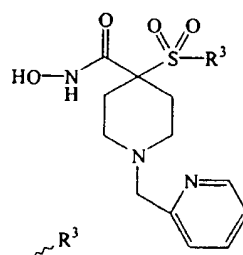
- 273 -

Table 144



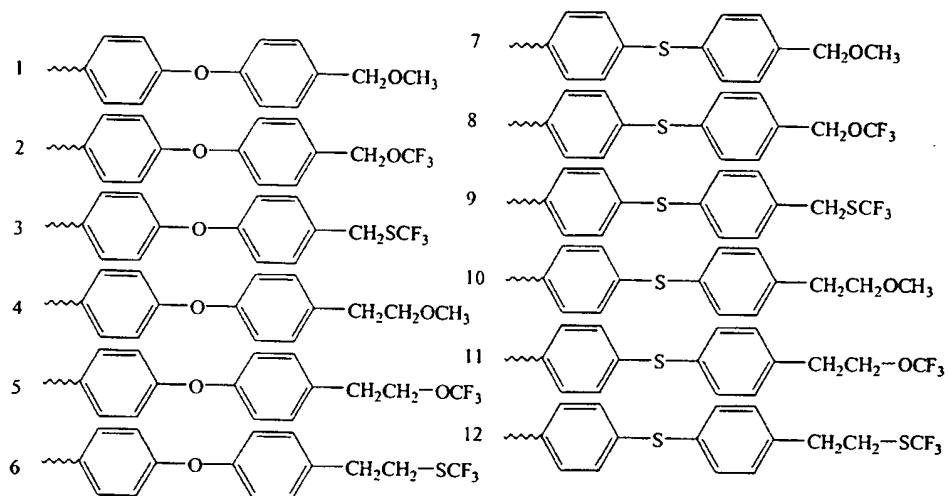
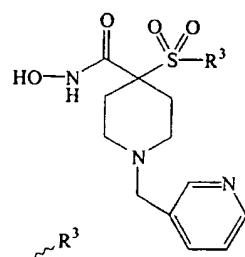
- 274 -

Table 145



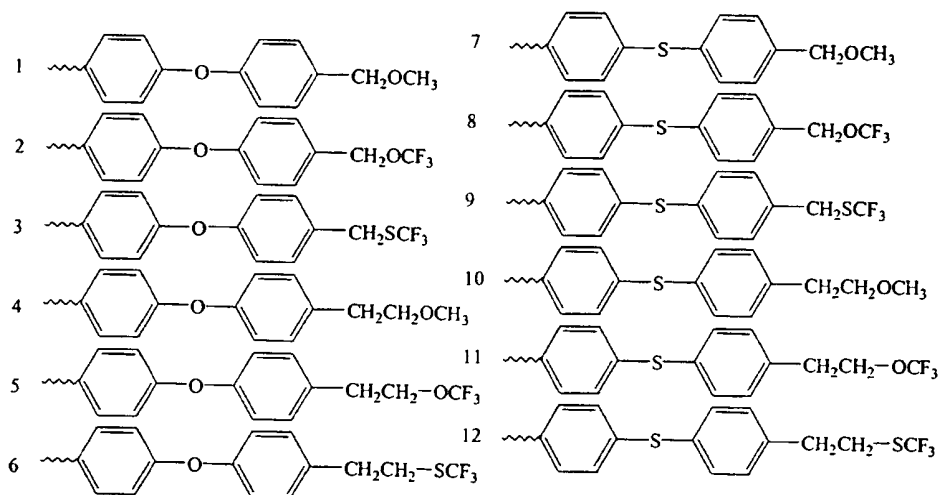
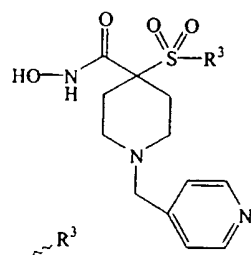
- 275 -

Table 146



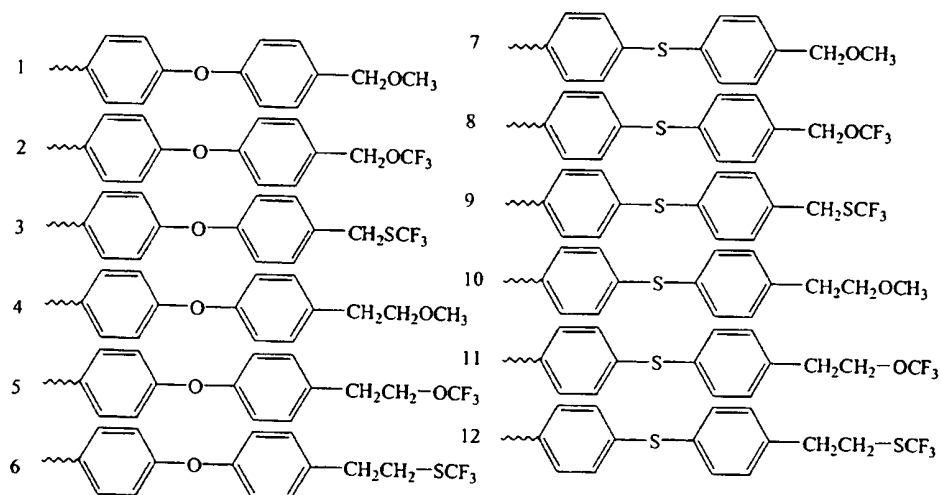
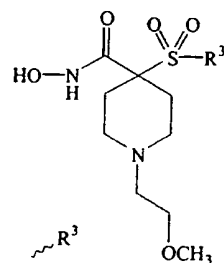
- 276 -

Table 147



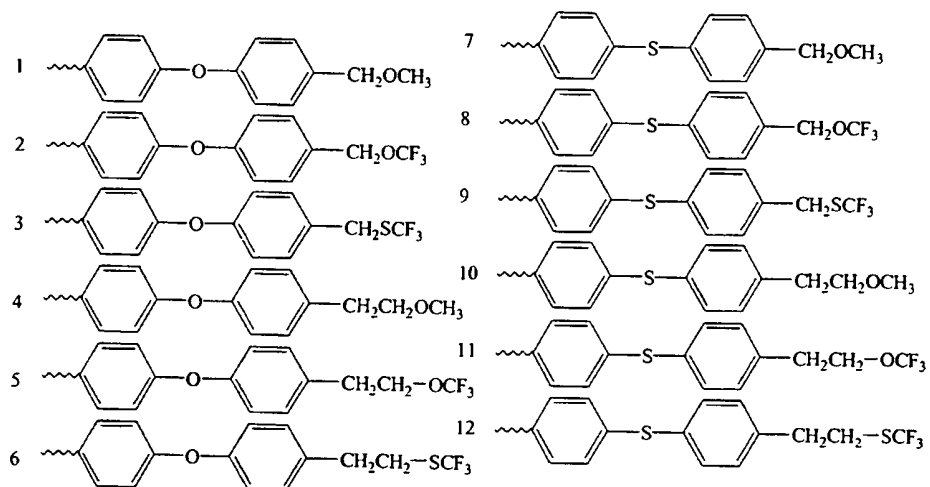
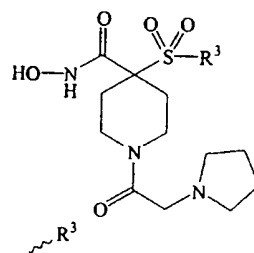
-277-

Table 148



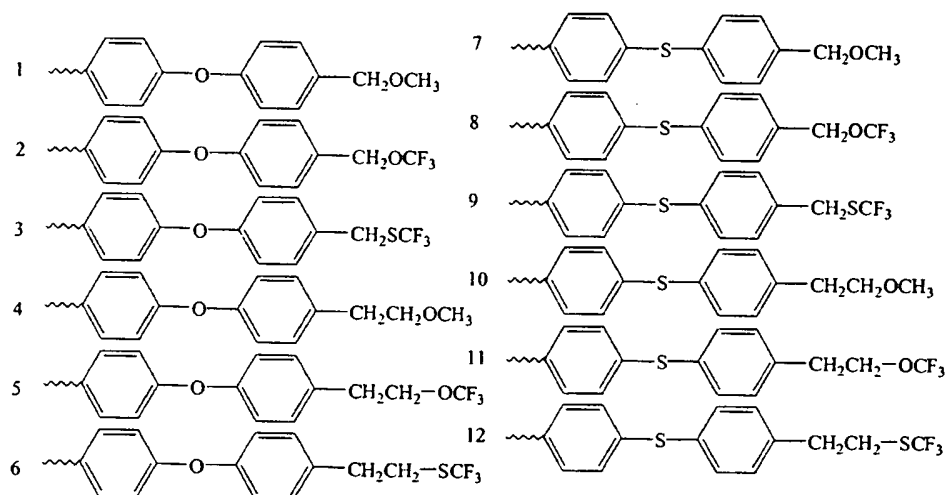
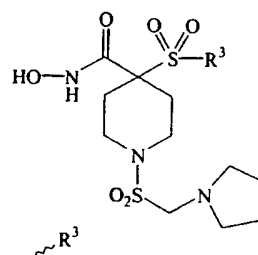
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Table 149



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Table 150



5

A contemplated inhibitor compound is used for treating a host mammal such as a mouse, rat, rabbit, dog, horse, primate such as a monkey, chimpanzee or human that has a condition associated with pathological matrix metalloprotease activity.

Also contemplated is use of a contemplated metalloprotease inhibitor compound in the treatment of a disease state that can be affected by the activity of metalloproteases TNF- α convertase.

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Exemplary of such disease states are the acute phase responses of shock and sepsis, coagulation responses, hemorrhage and cardiovascular effects, fever and inflammation, anorexia and cachexia.

5 In treating a disease condition associated with pathological matrix metalloproteinase activity, a contemplated MMP inhibitor compound can be used in the form of an amine salt derived from an inorganic or organic acid. Exemplary salts include but are not
10 limited to the following: acetate, adipate, alginate, citrate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, camphorate, camphorsulfonate, digluconate, cyclopentanepropionate, dodecylsulfate, ethanesulfonate, glucoheptanoate, glycerophosphate,
15 hemisulfate, heptanoate, hexanoate, fumarate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxy-ethanesulfonate, lactate, maleate, methanesulfonate, nicotinate, 2-naphthalenesulfonate, oxalate, palmoate, pectinate, persulfate, 3-phenylpropionate,
20 picrate, pivalate, propionate, succinate, tartrate, thiocyanate, tosylate, mesylate and undecanoate.

Also, a basic nitrogen-containing group can be quaternized with such agents as lower alkyl
halides, such as methyl, ethyl, propyl, and butyl
25 chloride, bromides, and iodides; dialkyl sulfates like dimethyl, diethyl, dibutyl, and diamyl sulfates, long chain halides such as decyl, lauryl, myristyl and stearyl chlorides, bromides and iodides, aralkyl halides like benzyl and phenethyl bromides, and
30 others to provide enhanced water-solubility. Water or oil-soluble or dispersible products are thereby obtained as desired. The salts are formed by combining the basic compounds with the desired acid.

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Other compounds useful in this invention that are acids can also form salts. Examples include salts with alkali metals or alkaline earth metals, such as sodium, potassium, calcium or magnesium or
5 with organic bases or basic quaternary ammonium salts.

In some cases, the salts can also be used as an aid in the isolation, purification or resolution of the compounds of this invention.

10 Total daily dose administered to a host mammal in single or divided doses can be in amounts, for example, for 0.001 to 30 mg/kg body weight daily and more usually 0.01 to 10 mg. Dosage unit compositions can contain such amounts or submultiples
15 thereof to make up the daily dose. A suitable dose can be administered, in multiple sub-doses per day. Multiple doses per day can also increase the total daily dose, should this be desired by the person prescribing the drug.

20 The dosage regimen for treating a disease condition with a compound and/or composition of this invention is selected in accordance with a variety of factors, including the type, age, weight, sex, diet and medical condition of the patient, the severity of
25 the disease, the route of administration, pharmacological considerations such as the activity, efficacy, pharmacokinetic and toxicology profiles of the particular compound employed, whether a drug delivery system is utilized and whether the compound
30 is administered as part of a drug combination. Thus, the dosage regimen actually employed can vary widely and therefore can deviate from the preferred dosage regimen set forth above.

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A compound of the present invention can be formulated as a pharmaceutical composition. Such a composition can then be administered orally, parenterally, by inhalation spray, rectally, or
5 topically in dosage unit formulations containing conventional nontoxic pharmaceutically acceptable carriers, adjuvants, and vehicles as desired. Topical administration can also involve the use of transdermal administration such as transdermal
10 patches or iontophoresis devices. The term parenteral as used herein includes subcutaneous injections, intravenous, intramuscular, intrasternal injection, or infusion techniques. Formulation of drugs is discussed in, for example, Hoover, John E.,
15 Remington's Pharmaceutical Sciences, Mack Publishing Co., Easton, Pennsylvania; 1975 and Liberman, H.A. and Lachman, L., Eds., Pharmaceutical Dosage Forms, Marcel Decker, New York, N.Y., 1980.

Injectable preparations, for example,
20 sterile injectable aqueous or oleaginous suspensions can be formulated according to the known art using suitable dispersing or wetting agents and suspending agents. The sterile injectable preparation can also be a sterile injectable solution or suspension in a
25 nontoxic parenterally acceptable diluent or solvent, for example, as a solution in 1,3-butanediol. Among the acceptable vehicles and solvents that can be employed are water, Ringer's solution, and isotonic sodium chloride solution. In addition, sterile,
30 fixed oils are conventionally employed as a solvent or suspending medium. For this purpose any bland fixed oil can be employed including synthetic mono- or diglycerides. In addition, fatty acids such as

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oleic acid find use in the preparation of injectables. Dimethyl acetamide, surfactants including ionic and non-ionic detergents, polyethylene glycols can be used. Mixtures of
5 solvents and wetting agents such as those discussed above are also useful.

Suppositories for rectal administration of the drug can be prepared by mixing the drug with a suitable nonirritating excipient such as cocoa
10 butter, synthetic mono- di- or triglycerides, fatty acids and polyethylene glycols that are sold at ordinary temperatures but liquid at the rectal temperature and will therefore melt in the rectum and release the drug.

15 Solid dosage forms for oral administration can include capsules, tablets, pills, powders, and granules. In such solid dosage forms, the compounds of this invention are ordinarily combined with one or more adjuvants appropriate to the indicated route of
20 administration. If administered per os, a contemplated aromatic sulfone hydroximate inhibitor compound can be admixed with lactose, sucrose, starch powder, cellulose esters of alkanolic acids, cellulose alkyl esters, talc, stearic acid, magnesium stearate,
25 magnesium oxide, sodium and calcium salts of phosphoric and sulfuric acids, gelatin, acacia gum, sodium alginate, polyvinylpyrrolidone, and/or polyvinyl alcohol, and then tableted or encapsulated for convenient administration. Such capsules or
30 tablets can contain a controlled-release formulation as can be provided in a dispersion of active compound in hydroxypropylmethyl cellulose. In the case of capsules, tablets, and pills, the dosage forms can

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also comprise buffering agents such as sodium citrate, magnesium or calcium carbonate or bicarbonate. Tablets and pills can additionally be prepared with enteric coatings.

5 For therapeutic purposes, formulations for parenteral administration can be in the form of aqueous or non-aqueous isotonic sterile injection solutions or suspensions. These solutions and suspensions can be prepared from sterile powders or
10 granules having one or more of the carriers or diluents mentioned for use in the formulations for oral administration. A contemplated aromatic sulfone hydroximate inhibitor compound can be dissolved in water, polyethylene glycol, propylene glycol,
15 ethanol, corn oil, cottonseed oil, peanut oil, sesame oil, benzyl alcohol, sodium chloride, and/or various buffers. Other adjuvants and modes of administration are well and widely known in the pharmaceutical art.

Liquid dosage forms for oral administration
20 can include pharmaceutically acceptable emulsions, solutions, suspensions, syrups, and elixirs containing inert diluents commonly used in the art, such as water. Such compositions can also comprise adjuvants, such as wetting agents, emulsifying and
25 suspending agents, and sweetening, flavoring, and perfuming agents.

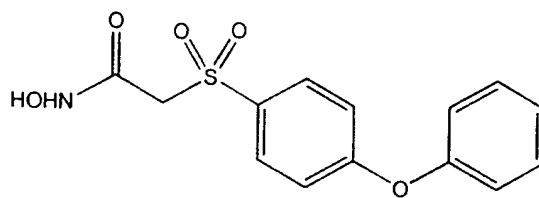
The amount of active ingredient that can be combined with the carrier materials to produce a single dosage form varies depending upon the
30 mammalian host treated and the particular mode of administration.

Best Mode For Carrying Out The Invention

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Without further elaboration, it is believed that one skilled in the art can, using the preceding description, utilize the present invention to its fullest extent. The following preferred specific
5 embodiments are, therefore, to be construed as merely illustrative, and not limiting of the remainder of the disclosure in any way whatsoever.

Example 1: Preparation of N-hydroxy-2-[(4-
10 phenoxyphenyl)sulfonyl]acetamide



Part A: To a solution of 3-bromopyruvic
15 acid hydrate (1.95 g, 11.7 mmol) cooled to zero degrees Celsius in methanol (50 mL) was added 4-(phenoxy)benzenethiol (2.35 g, 11.7 mmol). The solution was stirred for 15 minutes followed by concentration in vacuo. The residue was partitioned
20 between ethyl acetate and H₂O and the organic layer was dried over magnesium sulfate. Concentration in vacuo provided the crude sulfide as a yellow solid that was used without any additional purification.

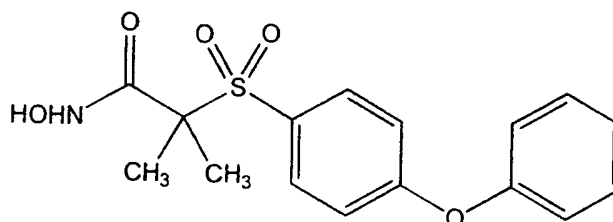
Part B: To a solution of the crude sulfide
25 of part A (1.2 g, <2.6 mmol) in methanol/H₂O cooled to zero degrees Celsius was added Oxone® (3.5 g, 5.72 mmol). The solution was stirred for 1 hour followed by removal of excess Oxone® by filtration. The

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filtrate was concentrated and the residue was dissolved into ethyl acetate and washed with saturated NaHCO_3 and saturated NaCl and dried over magnesium sulfate. After concentration in vacuo the resulting residue was dissolved into methanol and thionyl chloride (1.9 mL, 26 mmol) was added. Chromatography (on silica, ethyl acetate/hexane) provided the sulfone as a solid (350 mg, 44%). MS(CI) MH^+ calculated for $\text{C}_{15}\text{H}_{14}\text{O}_5\text{S}$: 307, found 307.

Part C: To a solution of the sulfone (350 mg, 1.1 mmol) in methanol (2 mL) and THF (THF; 2 mL) was added 50 percent aqueous hydroxylamine (1 mL). The solution was stirred overnight. Trituration with ethyl acetate provided the title compound as a white solid (270 mg, 77%). HPLC purity: >97%. MS(CI) MH^+ calculated for $\text{C}_{14}\text{H}_{13}\text{NO}_5\text{S}$: 308, found 308.

Example 2: Preparation of N-hydroxy-2-methyl-2-[(4-phenoxyphenyl)sulfonyl]propanamide



Part A: To a solution of 4-(phenoxy)benzenethiol (3.8 g, 18.8 mmol) in methanol (60 mL) cooled to zero degrees Celsius was added t-butyl bromoacetate (2.8 mL, 18.8 mmol) and triethylamine (2.6 mL, 19.0 mmol). The solution was

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stirred for 30 minutes and was then concentrated in vacuo. The residue was partitioned between ethyl acetate and H₂O and the organic layer was washed with saturated NaCl and dried over magnesium sulfate.

5 Concentration in vacuo provided the sulfide as an oil. To a solution of the sulfide in dichloromethane (85 mL) was added m-chloroperbenzoic acid (13.8 g, 43.2 mmol) over 15 minutes. The solution was stirred at ambient temperature for 2 hours. The reaction was
10 quenched by the addition of aqueous Na₂SO₃. After 30 minutes the solution was filtered through Celite®. The filtrate was washed with 25 percent aqueous hydroxylamine, 1N HCl, and saturated NaCl and dried over magnesium sulfate. Chromatography (on silica,
15 ethyl acetate/hexane) provided the sulfone as a white solid (4.0 g, 68%).

Part B: To a solution of the sulfone of part A (3.2 g, 9.2 mmol) in THF (65 mL) cooled to zero degrees Celsius was added sodium hydride (730 mg
20 of a 60 percent dispersion in mineral oil, 18.4 mmol). After 10 minutes, methyl iodide (2.28 mL, 36.8 mmol) was added dropwise and the mixture was stirred for 18 hours at ambient temperature. The reaction was quenched with H₂O and concentrated in
25 vacuo. The aqueous residue was diluted with ethyl acetate and the organic phase was washed with H₂O and dried over Na₂SO₄. Concentration in vacuo provided the dimethyl compound as an off-white solid (3.2 g, 92%). HPLC purity: 95%.

30 Part C: To a solution of the dimethyl compound of part B (3.2 g, 8.5 mmol) in anisole (10

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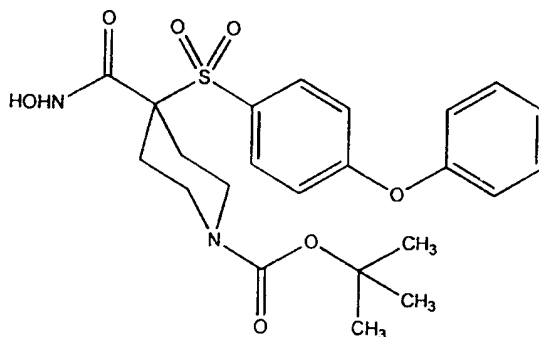
mL) was added trifluoroacetic acid (30 mL) and the solution was stirred for 30 minutes. Concentration in vacuo followed by trituration (ethyl ether) provided the acid as a white solid (750 mg, 28%).

5 HPLC purity: 99%. MS(CI) MH⁺ calculated for C₁₆H₁₆O₅S: 321, found 321.

Part D: To a solution of the acid of part C (723 mg, 2.26 mmol) in DMF (DMF; 4.5 mL) was added N-hydroxybenzotriazole•H₂O (HOBT; 366 mg, 2.71 mmol)
10 and 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride (EDC; 476 mg, 2.49 mmol). After the solution was stirred for 1 hour at ambient temperature 50 percent aqueous hydroxylamine (0.40 mL, 6.8 mmol) was added. After 15 minutes the
15 solution was partitioned between ethyl acetate and H₂O. The organic layer was washed with H₂O and saturated NaCl and dried over Na₂SO₄. Reverse phase chromatography (on silica, acetonitrile/H₂O) provided the title compound as a white foam (434 mg, 57%).
20 HPLC purity: 99%. MS(CI) M+Li⁺ calculated for C₁₆H₁₇NO₅O: 342, found 342.

Example 3: Preparation of 1,1-dimethylethyl ester
4 - [(hydroxyamino)carbonyl] - 4 -
25 [(phenoxyphenyl)-sulfonyl] - 1 -
piperidinecarboxylic acid

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Part A: A solution of 4-(phenoxy)benzenethiol
(2.03 g, 10.0 mmol) in DMSO (DMSO; 20 mL) was heated
5 to sixty-five degrees Celsius for 5 hours. The
solution remained at ambient temperature for 18
hours. The solution was extracted with ethyl acetate
and the combined organic layers were washed with H₂O
and saturated NaCl and dried over magnesium sulfate.
10 Concentration in vacuo provided the disulfide as a
yellow oil (2.3 g, quantitative yield).

Part B: To a solution of ethyl
isonipecotatate (15.7 g, 0.1 mol) in THF (100 mL) was
added a solution of di-tert-butyl dicarbonate (21.8
15 g, 0.1 mol) in THF (5 mL) dropwise over 20 minutes.
The solution was stirred overnight at ambient
temperature and concentrated in vacuo to yield a
light oil. The oil was filtered through silica gel
(7:3 ethyl acetate/hexanes) and concentrated in vacuo
20 to give the BOC-piperidine compound (26.2 g,
quantitative yield) as a clear, colorless oil.

Part C: To a solution of diisopropylamine
(2.8 mL, 20 mmol) in THF (30 mL), cooled to minus
seventy-eight degrees Celsius, was added n-butyl
25 lithium (12.5 mL, 20 mmol) dropwise. After 15

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minutes, the BOC-piperidine compound of part B (2.6 g, 10 mmol) in THF (10 mL) was added dropwise. After 1.5 hours the solution was cooled to minus sixty degrees Celsius and the disulfide of part A (2.0 g, 10 mmol) in THF (7 mL). The solution was stirred at ambient temperature for 2 hours. The solution was diluted with H₂O and extracted with ethyl acetate. The organic layer was washed with H₂O and saturated NaCl and dried over magnesium sulfate.

Chromatography (on silica, ethyl acetate/hexane) provided the sulfide as an oil (1.8 g, 40%).

Part D: To a solution of the sulfide of part C (1.8 g, 3.95 mmol) in dichloromethane (75 mL) cooled to zero degrees Celsius, was added m-chloroperbenzoic acid (1.7 g, 7.9 mmol). The solution was stirred for 1.5 hours followed by dilution with H₂O and extraction with dichloromethane. The organic layer was washed with 10 percent Na₂SO₄, H₂O, and saturated NaCl and dried over magnesium sulfate. Chromatography (on silica, ethyl acetate/hexane) provided the sulfone as a solid (1.15 g, 59%).

Part E: To a solution of the sulfone of part D (800 mg, 1.63 mmol) in THF (9 mL) and ethanol (9 mL) was added NaOH (654 mg, 16.3 mmol) in H₂O (3 mL). The solution was heated at sixty-five degrees Celsius for 18 hours. The solution was concentrated in vacuo and the residue was dissolved in H₂O. Following acidification with 2N HCl to pH 4, the solution was extracted with ethyl acetate and the organic layer was washed with saturated NaCl and

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dried over magnesium sulfate. Concentration in vacuo provided the acid as a white foam (790 mg, quantitative yield). Analytical calculated for $C_{23}H_{27}NO_7S$: C, 59.86; H, 5.90; N, 3.04; S, 6.95. Found:

5 C, 59.49; H, 6.37; N, 2.81; S, 6.59.

Part F: To a solution of the acid of part G (730 mg, 1.58 mmol) in DMF (9 mL) was added HOBT (256 mg, 1.90 mmol) followed by EDC (424 mg, 2.21 mmol), 4-methylmorpholine (0.521 mL, 4.7 mmol) and 50

10 percent aqueous hydroxylamine (1.04 mL, 15.8 mmol). The solution was stirred for 20 hours and additional N-hydroxybenzotriazole•H₂O (256 mg), EDC (424 mg) and 50 percent aqueous hydroxylamine (1.04 mL) were added. After an additional 24 hours of stirring the solution

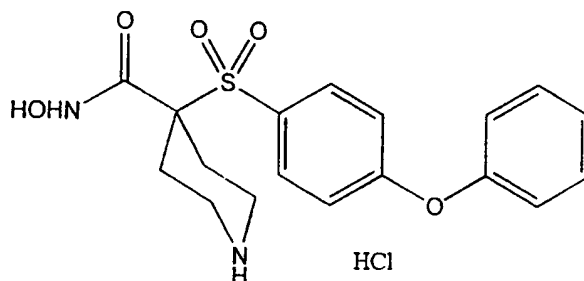
15 was diluted with H₂O and extracted with ethyl acetate and the organic layer was washed with saturated NaCl and dried over magnesium sulfate. Reverse phase chromatography (on silica, acetonitrile/H₂O) provided the title compound as a white solid (460 mg, 61%).

20 HPLC purity: >99%. Analytical calculated for $C_{23}H_{28}N_2O_7S$: C, 57.97; H, 5.92; N, 5.88; S, 6.73. Found: C, 57.95; H, 6.02; N, 5.81; S, 6.85.

Example 4: Preparation of N-hydroxy-4-[(4-phenoxyphenyl)sulfonyl]-4-piperidinecarboxamide,

25 monohydrochloride

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Part A: A solution of 4-(phenoxy)benzenethiol (2.03 g, 10.0 mmol) in DMSO (20 mL) was heated to sixty-five degrees Celsius for 5 hours. The solution remained at ambient temperature for 18 hours. The solution was extracted with ethyl acetate and the combined organic layers were washed with H₂O and saturated NaCl and dried over magnesium sulfate. Concentration in vacuo provided the disulfide as a yellow oil (2.3 g, quantitative yield).

Part B: To a solution of ethyl isonipecotate (15.7 g, 0.1 mol) in THF (100 mL) was added a solution of di-tert-butyl dicarbonate (21.8 g, 0.1 mol) in THF (5 mL) dropwise over 20 minutes. The solution was stirred overnight at ambient temperature and concentrated in vacuo to yield a light oil. The oil was filtered through silica gel (on silica, ethyl acetate/hexane) and concentrated in vacuo to give the BOC-piperidine compound as a clear, colorless oil (26.2 g, quantitative yield).

Part C: To a solution of diisopropylamine (2.8 mL, 20 mmol) in THF (30 mL), cooled to minus seventy-eight degrees Celsius, was added n-butyl lithium (12.5 mL, 20 mmol) dropwise. After 15